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Journal Section
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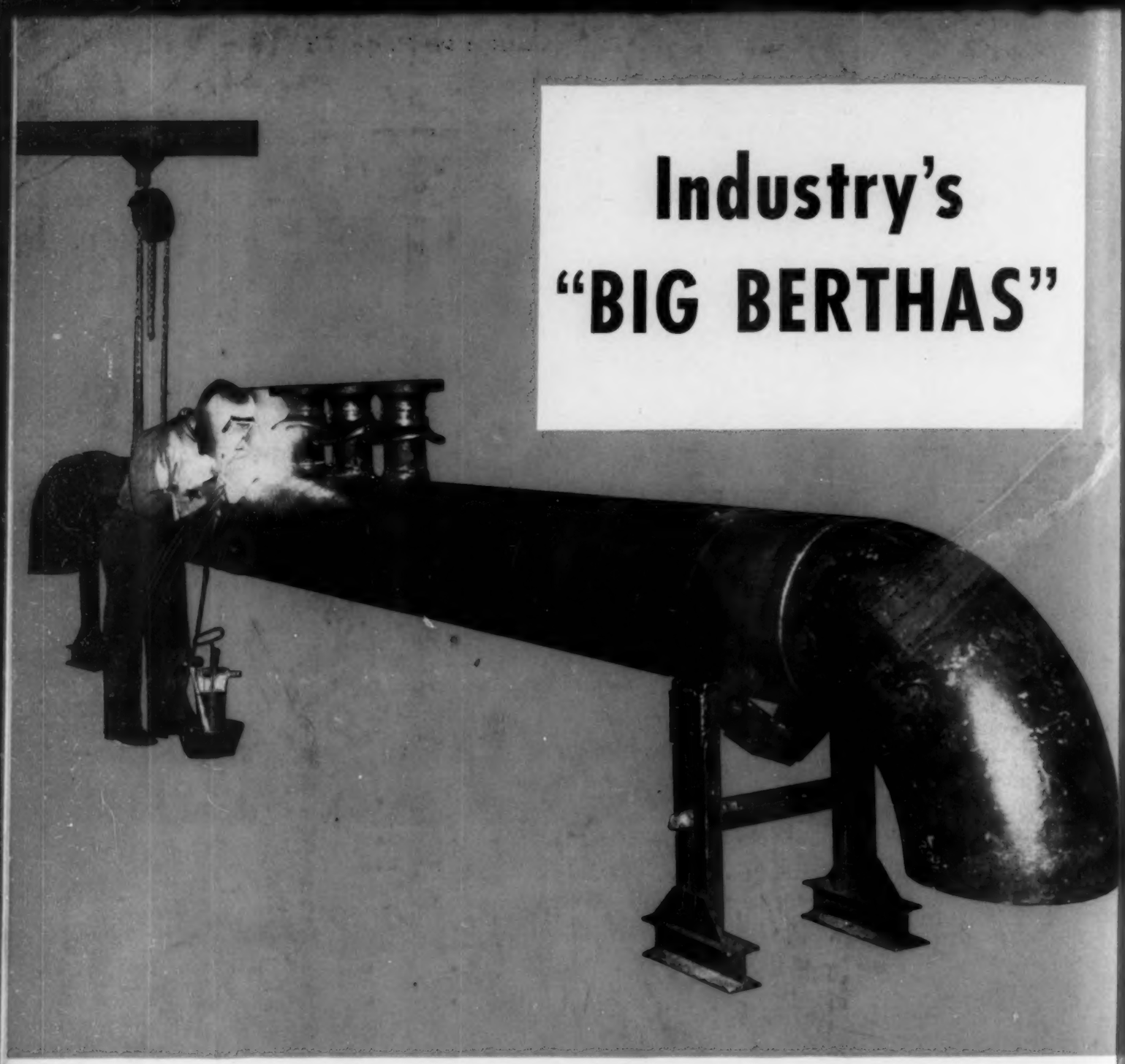

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WHENEVER **PIPING** IS INVOLVED

The Editor's Pages

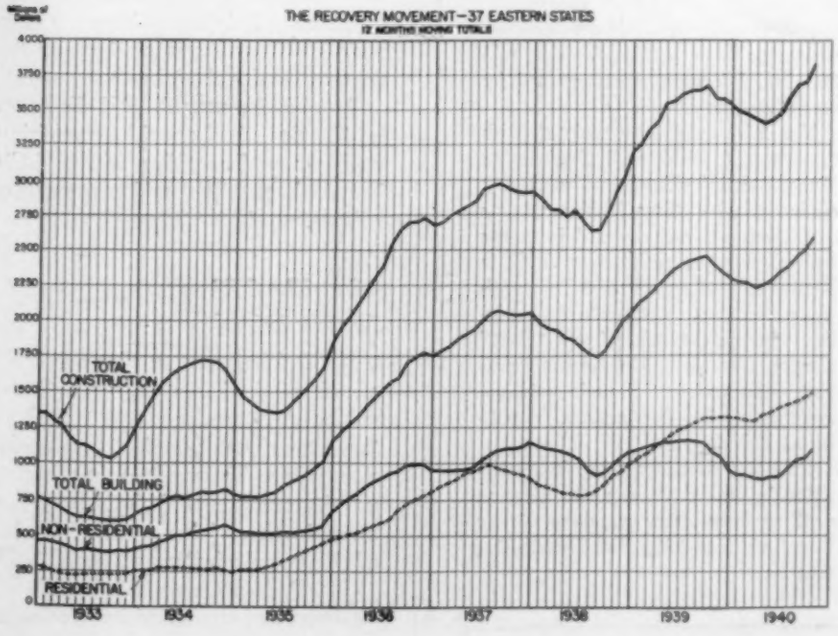
DODGE ANTICIPATES LARGEST CONSTRUCTION VOLUME SINCE 1930

The largest construction volume since 1930 is anticipated this year by F. W. Dodge Corp. Estimating the 1940 building and engineering contract total for 37 eastern states at $3,850,000,000, the figure for 1941 is set at $4,400,000,000, an indicated over-all increase of 14 per cent.

Construction for the defense program is expected to dominate the year's activities, to run to very large volume during the first half of the year and to carry a distinct possibility of enlargement if additional appropriations are made by the next congress. Concurrent with large amounts of army, navy, air corps, defense industry and defense housing construction, continually increasing industrial production activity and industrial employment are anticipated, with stimulating effects on national income and private building demand (commercial, manufacturing, and residential buildings and electric utility construction). Translation of this potential private demand into actual building and engineering contracts will hinge upon two important factors: (1) Whether potential construction industry capacity is adequate to carry the double load of largely increased public and private demand. (2) Whether building cost increases remain within reasonable bounds.

As Dodge analyzes the situation, temporary local shortages of certain classes of materials and certain categories of skilled labor are likely to occur, particularly during the peak period of cantonment building. Such conditions may very well cause temporary deferment of some private building projects and even of some defense housing projects. No extended period during which private building would have to be long deferred or abandoned as a direct result of government priorities is anticipated for 1941.

More uncertain, according to Dodge, is the prospect for stable building costs. It is pointed out, however, that while market demand factors tend strongly in the direction of the building cost inflation which has always in times past accompanied armament and war programs, consciousness of the disastrous effects of price inflation upon the whole economy is today keener and more widespread than ever before and efforts to exert all possible controls will be applied by leaders in industry, labor, and government. Dodge analysis indicates a probability that building cost increases will remain within moderate bounds during most, if not all, of 1941.



Pointing out that the very large volume of defense construction that will take place can scarcely constitute a net addition to the program of private construction that would normally develop in a year of record-breaking industrial productivity, and also the unusual uncertainties of the situation, Dodge cautions against over-optimistic estimates of 1941 volume increases, indicating that budgeting of sales and production plans by building material producers should preferably err on the side of conservatism.

The estimates include, in detail, the following items: non-residential building volume in the 37 eastern states, $1,400,000,000 in 1941 compared with $1,200,000,000 in 1940, an estimated increase of 17 per cent; residential building volume, to increase from $1,530,000,000 in 1940 to $1,700,000,000 in 1941, an indicated rise of 11 per cent; public works and utilities construction, to increase from $1,120,000,000 in 1940 to $1,300,000,000 in 1941. These estimates anticipate the largest volume of public building and engineering work on record, coupled with a moderate increase in private construction.

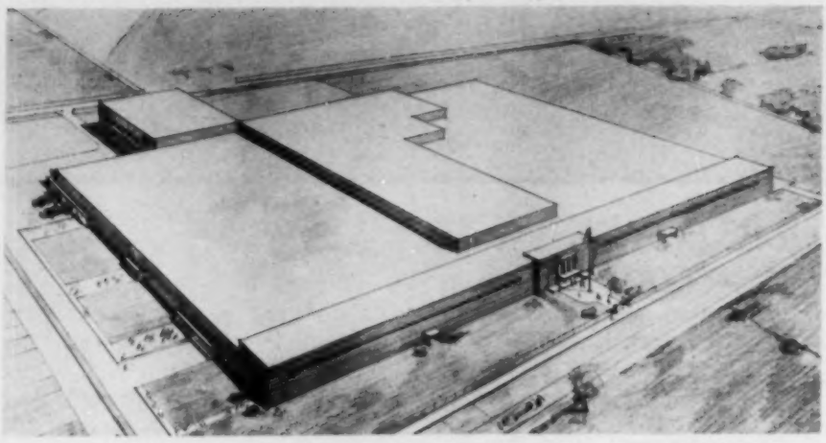
AIR CONDITIONING FOR CANAL ZONE AIR FIELD

A $130,000 contract for refrigerating and air conditioning for air corps technical buildings at Albrook field in the Canal Zone was recently awarded to Baker Ice Machine Co. The buildings included in the contract are the air corps depot supply building, the equipment repair building, the engine test building and the engine repair shop.

In the depot supply building, re-

frigeration is to be supplied for two clothing storage rooms by means of a duct system of supply and return air cooled by two exterior unit coolers. Automatic control is to be provided by two thermostats for each room, one for high temperature and one for low temperature, with a thermostat transfer switch. The low temperature of 10 F within the room is to be operated for a period of five days during the month, and a temperature of 35 F is to be maintained for 25 days of the month.

Air conditioning is to be provided for both stories of the equipment repair building, used primarily for repair and maintenance of instruments, bomb sights, parachute drying well and armament repairs. Conditioned air is to be circulated through a duct system on the first and second floors, divided into six zones. Cooling is to be accomplished by means of an extended fin and tube direct expansion cooling coil. Refrigeration is to be supplied by "Freon" condensing units with automatic control accomplished by a gradual acting type duct thermostat in the refrigerated section.



This large blackout factory for Grumman Aircraft Engineering Corp. at Bethpage, Long Island, designed by the Austin Co., will have nearly half a million square feet of floor space lighted primarily by fluorescent tubes and air conditioned. Four thousand men will be employed in the new plant, which is scheduled for completion in 120 working days. Two service trenches extending the full length of the assembly floor will make power, compressed air and other facilities available at any point in the line, to meet the requirements of small hand tools, hydraulic lifts, and other equipment

F. E. GIESECKE, R. E. HIERONYMUS, A. C. KIRKWOOD BECOME MEMBERS OF HPAC EDITOR BOARD

HEATING, PIPING AND AIR CONDITIONING announces with pleasure the addition this month of three new names to its Board of Consulting and Contributing Editors, the complete membership of which is shown on our Contents page. The new members are F. E. Giesecke, R. E. Hieronymus and A. C. Kirkwood.

Dr. Giesecke is professor emeritus of heating, ventilating and air conditioning at the Agricultural and Mechanical College of Texas, and is the national president of the American Society of Heating and Ventilating Engineers. He is well-known as an authority on hot water heating and has been responsible for much of the data used in the design of such systems. During the past year, he has contributed greatly—both in the pages of HPAC and in talks before various groups throughout the United States—to the subject of radiant heating and cooling. His series on radiant heating and cooling, published in HPAC last year, represents probably as complete information on the subject as is available anywhere.

Mr. Hieronymus is general superintendent of Aldis & Co., prominent real estate and management company of Chicago, with many large buildings in the Loop area under his direction. He has been very active in affairs of the building owners and managers association and is well-known to readers of HPAC through many articles we have published. Mr. Hieronymus and his associates have done outstanding work in promoting economy of heating, and he has explained his methods for achieving heating economy on many occasions in our pages. He has also written informative articles on operation and cost of air conditioning, which we have published. You will find Mr. Hieronymus represented by an article this month.

Mr. Kirkwood is associated with the Burns & McDonnell Engineering Co., a 40 year old firm of consulting engineers with offices in Kansas City and Cincinnati and engaged in power and water plant design work. He is known to readers of HPAC through his articles on industrial plant piping, wherein the "Chief" and "Gard" discuss plant piping problems and present information for their solution. Another of his fine articles is published this month.

You will find in coming issues articles by all of these authorities, as well as from other members of our Board of Consulting and Contributing Editors.

L. L. LEWIS HEADS ASRE

L. L. Lewis, vice-president in charge of engineering of Carrier Corp. and one of the early pioneers in air conditioning, was elected president of the American Society of Refrigerating Engineers last month. Mr. Lewis, who is credited with inventing the bypass system of air conditioning, served as vice-president of the group in 1940. During World War I, he performed invaluable service to the government by adapting air conditioning to the manufacture of munitions, fuses and powder, and recently he has pioneered again in introducing air conditioning into blast furnace operations, helping to increase iron and steel production during the present national defense program.

Among the new ASRE directors is Charles S. Leopold, consulting engineer and member of HPAC's board of consulting and contributing editors.

ASA ELECTS ZIMMERMAN

R. E. Zimmerman, vice-president of the United States Steel Corp., was elected president last month of the American Standards Association. Mr. Zimmerman has served as vice-president of the association since 1938, and has been a member of the board of directors since 1937.

R. P. Anderson was re-elected chairman of the standards council.

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Commercial, Industrial
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Published monthly by the Keeney Publishing Company, 6 N. Michigan Ave., Chicago. Telephone: State 6916/ F. P. Keeney, President; W. J. Osborn, Vice-President; R. Payne Wettstein, Secretary; Chas. E. Price, Treasurer/ Address all correspondence to Chicago office/ New York office, Room 1734, Grand Central Terminal Bldg. Telephone: Murray Hill 9-8293/ Cleveland office, 2128 Rossmoor Road. Telephone: Yellowstone 1540/ Los Angeles office, 1406 S. Grand Ave. Telephone: Richmond 6191/ Subscriptions: U. S. and possessions, Canada, Mexico, Central America, South America, $2.00 per year; other, $4.00. Current copies, U. S. and possessions, 25c each, back copies 50c each. January, 1941, issue, $1.00 per copy/ Member of Audit Bureau of Circulations/ Member of The Associated Business Papers, Inc./

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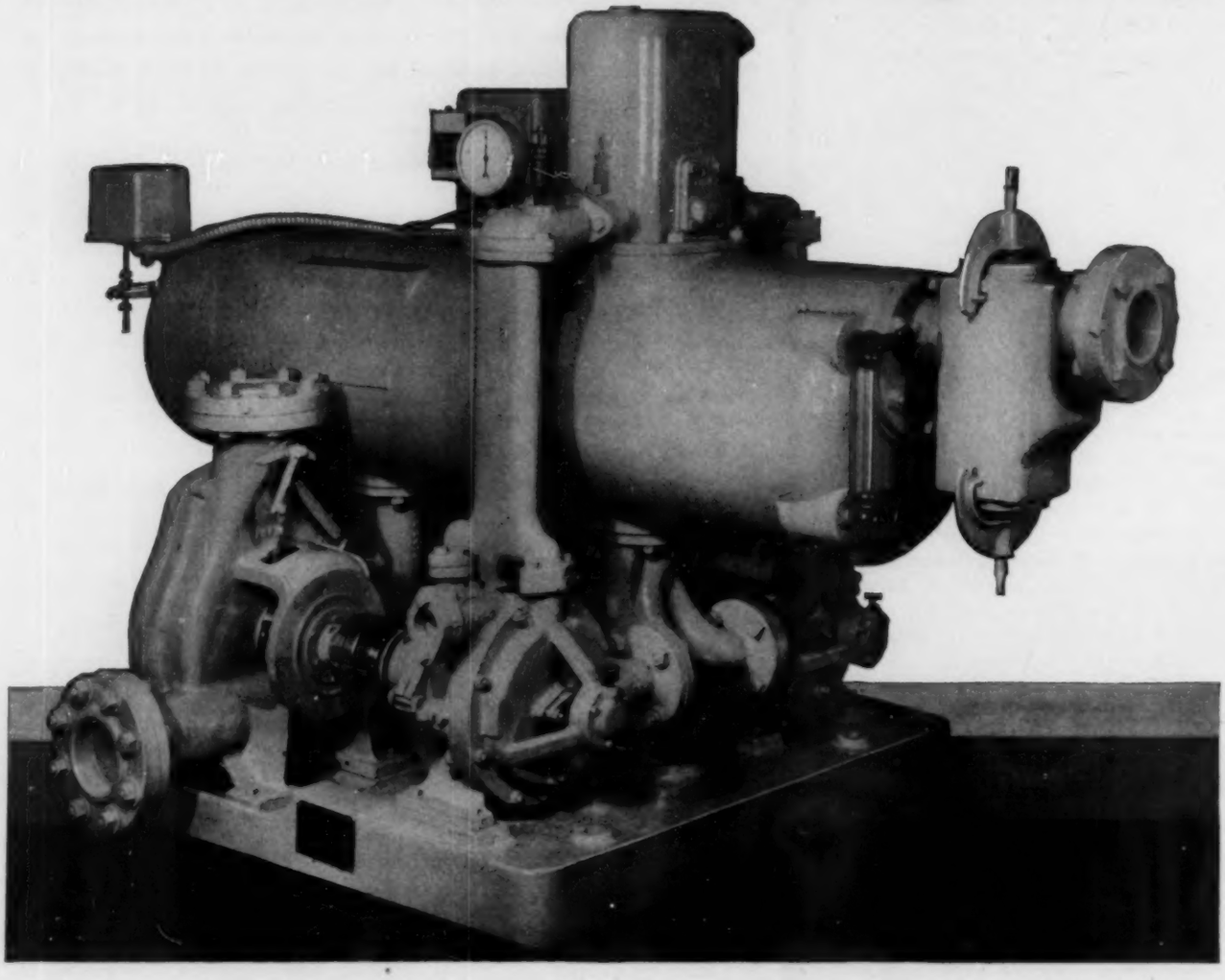
Where Heat Must Not Fail— Install this SAFE Heating Pump!



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Heating · Piping and Air Conditioning

Vol. 13, No. 1 • January, 1941

PLAN FOR PIPING MAINTENANCE

The Chief and Gard Check Up on Their Piping So Defense Orders Won't Be Delayed... By A. C. Kirkwood*

SUMMARY—Our old friends, the Chief and Gard, face some new problems in preventive maintenance, as their plant is now working on defense orders for the army. Their piping inspection schedule, which is aimed to avoid shutdowns and delays, is given here for the benefit of others faced with the same situation

MORNING, 'General.' How are you and all your new-found army friends?"

"O. K., Gard. I am still friends with army officers, inspectors, and regulations, but if....."

". . . if they don't let you go around the plant without being the only visible support for a celluloid medal, you'll tell someone where to head-in?"

"Not at all, Gard. These identification discs are all right. What I was going to say was that our military friends will leave us if we fail to keep production on schedule."

"Yeah, I know that one too, Chief. Preventive maintenance keeps the wheels of industry turning. The Old Man cracked that one last night at the Foremen's Club when he spilled the dope on the new army orders."

"If the Old Man has the right information, the orders we got this week are only a small start. He is so thoroughly convinced of future orders that we are to make plans for three-shift operations lasting not less than a year to a year-and-a-half."

"When do we organize the third shift, Chief?"

"It varies, but most departments will start not later than the first. Maintenance starts now, Gard."

"Ouch!"

"We must insure minimum outages before the first rolls around. Each division of the maintenance department will inspect all points of possible failure, renewing or replacing where necessary. In order to hold time and material to a reasonable amount and to obtain orderly work, I want you to rough out a schedule of items to be checked and a tentative procedure. Bear in mind that mechanical, electrical and structural maintenance must dovetail."

"O. K., Chief."

"Another point, Gard. Don't forget I am particularly interested in

"Isolate valves and equipment to be inspected and repaired, having first obtained clearance from production department and made proper coöperative arrangements with other maintenance crews"

*Burns & McDonnell Engineering Co., Consulting Engineers. Member of HPAC's Board of Consulting and Contributing Editors.

piping. Let me have an outline of your proposed procedure on piping before you leave this afternoon."

* * *

"Chief, here is 'General Order No. 1' for the maintenance division. If you'll approve it, we'll move in the morning."

"Good work, Gard. Let's go over it first, then we'll issue instructions. What's the story about?"

"Well, Chief, like you said to do, I wrote up a sort of outline about how to inspect and what to do about it. I think that these suggestions, plus our requisition forms, and plus some conversation, will get the job done pronto."

Piping Inspection Schedule

General Procedure:

Inspection falls into two classifications: (I) inspections possible regardless of time, and (II) inspections requiring pre-arranged periods of time when lines and equipment can be taken out of service for detailed inspection.

In the latter case, inspectors checking equipment, electrical devices and wiring, and structures should be working on the same equipment at the same time. This will prevent duplication of outages for inspection. Repair parts, equipment, and material that may be required should be available without delay.

Class I Inspection

These inspections can be made while lines and equipment are in operation.

Joints:

Inspect flanged and screwed joints for signs of leakage while under operating conditions. Record leaking joints, listing location and nature of leak, type of joint, pipe size and probable repair parts needed. Determine where possible cause of leak, such as misalignment, temperature stress or working of line, loose bolts, failure of gasket, failure of threads, corrosion, erosion, etc. If any of these causes are apparent and represent abnormal conditions, so note and where possible suggest specific remedies to prevent future failures.

Weeps in flanged joints may be stopped by carefully drawing up the bolts where such procedure is indicated clearly.

Valves:

Where operations will permit it, all stop valves should be tested under operating pressure and temperature to determine tightness, travel, ease of operation, etc. List apparent deficiencies and suggested repair materials required.

Regulating valves should be checked for functional operation, operating characteristics of valve controls or auxiliaries, including limit switches or stops. As to functional operation, operating or process records and process operators should be consulted. Record should be made of both operating deficiencies and desirable changes in characteristics. Special tests should be made if necessary to determine proper operation.

Check handwheels and look for gland leaks.

Hangers and Anchors:

See that pipes hang true to grade and line, without excessive sag at any point. Spring hangers should be checked for proper spring compression and freedom of action. Anchors should be checked for signs of slippage or failure.

Insulation and Painting:

Deteriorating insulation should be replaced or repaired. Painting should be touched up or redone where needed, particularly where painting is used as partial or complete designation of line contents. Designative stencilling should be redone if necessary.

Class II Inspection

These inspections must be made while lines or equipment are out of service. Repairs should be made coincident with inspection, if at all possible.

Joints:

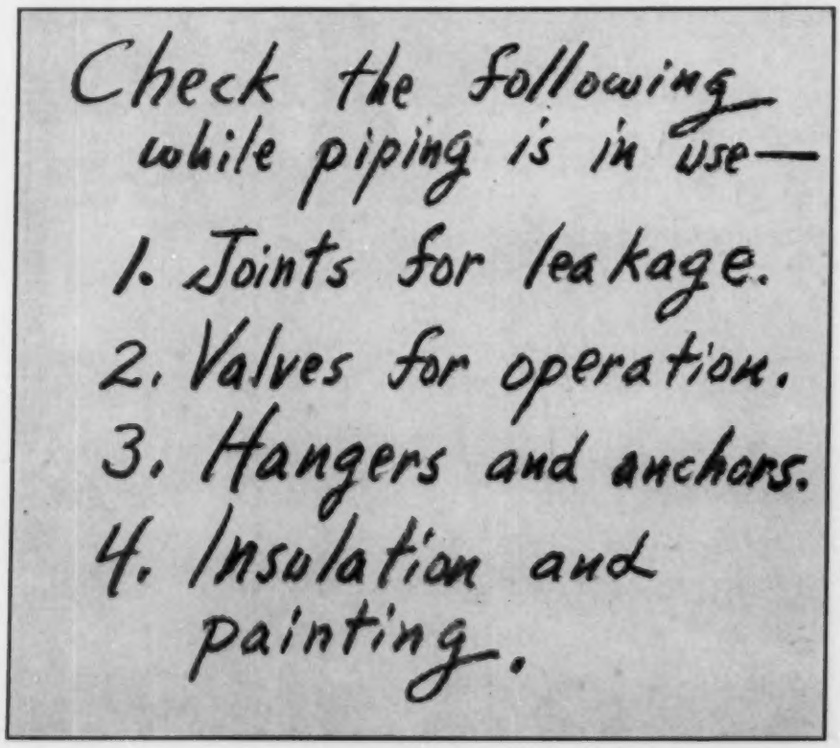
Where previously examined leaking joints need repair they should be checked for contributing causes such as misalignment of flange faces, breathing of lines, imperfect materials and so on. Remedy the cause where possible, or make provision for proper remedies at an early date. Bad joints should be repaired along with the valves in the same part of the system.

Valves:

Obtain and study record of valve troubles found by inspection made while valves were in operation. Isolate valves and equipment to be inspected and repaired, having first obtained clearance from production department and made proper coöperative arrangements with other maintenance crews.

The following comments apply to nearly all valves. Specific suggestions are given for particular types of valves.

Leaking valves should be checked for cause of leaks. Many leaks are caused by improper operation. For


Check the following while piping is in use—
1. Joints for leakage.
2. Valves for operation.
3. Hangers and anchors.
4. Insulation and painting.

instance, hot valves shut off where stem is on cold side will often leak after the stem has cooled and contracted unless the cooled valve has been shut further. In this case, repair the valves and educate the operator.

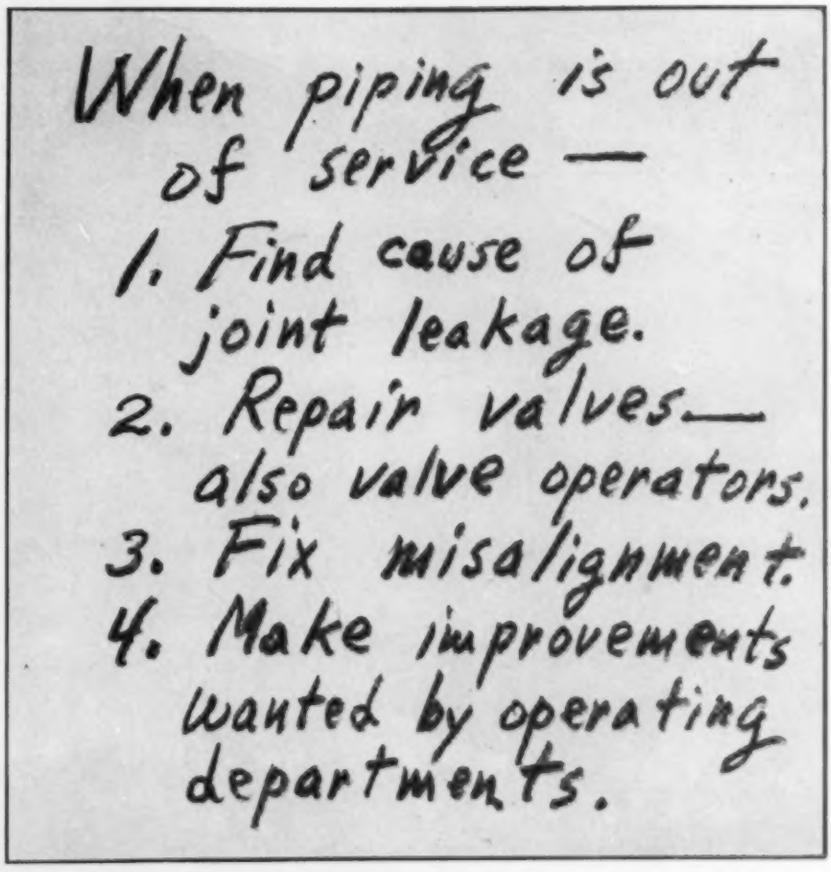
Foreign materials of an abrasive nature ruin seat and disc surfaces very quickly. Unless the fluid has to carry abrasives, they should be eliminated by cleaning the lines or by installing strainers or filters. Renewable disc or regrinding type valves should be repaired in place. Other types should be repaired either in place or in the shop by the use of special tools and trained men. Most reseating operations on gate valves should be done by the manufacturer.

Regrinding should be done before small blemishes have had an opportunity to become pronounced. Composition or soft alloy discs should likewise be replaced before the seats have eroded. Screwed-in seats or discs should be checked for leakage behind the threads, as should those with rolled or pressed-in rings.

While there is the opportunity, look for stem troubles such as corrosion in the stuffing box area, galling of threads or other sliding surfaces, and eroded back seating surfaces. Packing should be examined for condition and any unfit for further service should be replaced. Packing requiring excessive tightening of the gland bolts or stuffing nut may cause undue strains on the stem threads. Such packing should be replaced by more suitable material.

Cold steam valves when warming up may leak some water until they are hot. Valves with stainless steel stems and carbon packing should be watched for stem corrosion if moisture can get into the packing.

Check valves should be examined for freedom of operation as well as condition of seating surfaces. When closing valve bodies, see that bonnet gaskets are in good condition and that bolts are properly tightened.


When piping is out of service —
1. Find cause of joint leakage.
2. Repair valves— also valve operators.
3. Fix misalignment.
4. Make improvements wanted by operating departments.

Operators and Controls:

Valve operators and controls found in unsatisfactory condition during operating tests should be repaired. Limits should be checked for accuracy. Moving parts should be examined for wear. Lubricating devices should be checked to see that lubricating oil or grease is reaching all parts.

Alignment and Supports:

The cases of misalignment should be corrected by such means as are necessary. This is particularly true where such lack of alignment causes undesirable strains on pump and equipment connections. Supports that could not be worked while lines were hot should be repaired, replaced or added (as the case may be).

Miscellaneous:

Minor improvements often are desired by the operating departments. These improvements should be installed (if at all possible) while lines are out of service for inspection or repair.

FINANCING THE DEFENSE PROGRAM

In a recent address before the Institute of American Meat Packers, Harold G. Moulton, president of the Brookings Institute, concluded that it should be possible to finance our defense program without increasing the magnitude of current fiscal deficits, for he foresees an inevitable expansion of national income from about $70,000,000,000 at the present time to at least $80,000,000,000 within the course of the next year or so. An expansion of income from $70,000,000,000 to $80,000,000,000 means a very great increase in the potential revenue of the government.

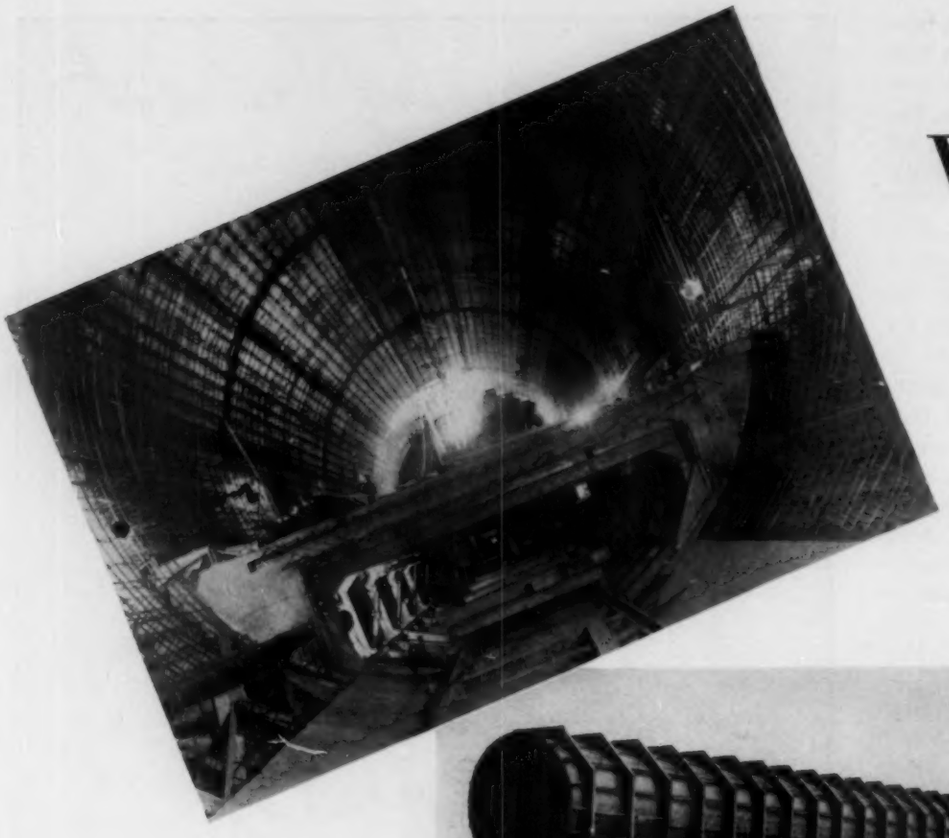
Fiscal Stability

Fuller utilization of our natural resources, which the war program involves, makes it possible to maintain fiscal stability, according to Dr. Moulton. The outcome will "depend primarily upon the degree of determination to maintain financial equilibrium manifested by the fiscal authorities, congressional and otherwise," he said.

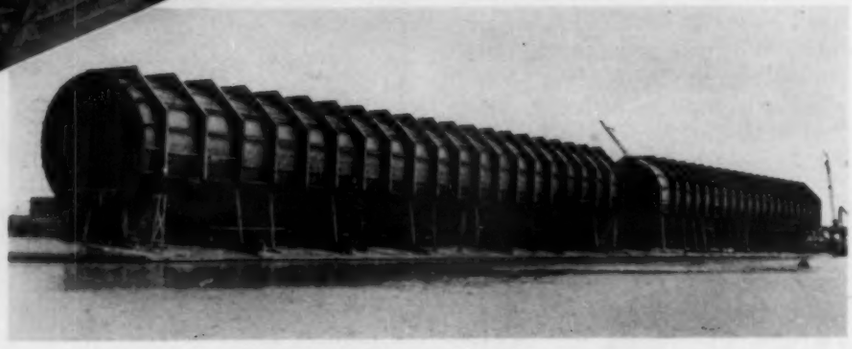
Tunnel Ventilation

By Ralph Smillie

Consulting Engineer



The Bankhead tunnel, nearing completion at Mobile, Ala., will provide a two lane vehicular crossing under the Mobile River and will shorten the approach to the city from the east by about 7½ miles. At present U. S. Route 90, which is the main highway along the Gulf Coast, and U. S. 31 from Birmingham and Montgomery, cross Mobile Bay on a causeway extending from the easterly side of the bay to Blakely Island, immediately across the Mobile River from the heart of the city. The road then turns north and follows the river to a lift bridge north of the city. The tunnel will not only eliminate this detour, but will cut out delays caused by the lift span and by traffic congestion in the city proper. The photograph above illustrates the interior of the tube with reinforcing steel and roadway forms in place. Two lanes of traffic moving in opposite directions will be provided by a roadway 21 ft wide between curbs. The tunnel proper is 3100 ft long between portals and a minimum of 45 ft below mean low water within the 500 ft channel



The river portion of the Bankhead tunnel has been built by the trench method. Sections 300 ft long are fabricated of welded steel plates and shapes on shipways near the site. Temporary steel bulkheads placed near the ends exclude water until the tunnel is in its final position. These sections are launched and partially concreted in dry dock. When the lower concrete has been poured, they are again floated and concreting is continued alongside a dock until but little freeboard remains. Prior to sinking, the river bed is dredged to a depth of about 2 ft deeper than the bottom of the tunnel in its final position. The nearly concreted sections are then brought into position and sinking completed by the addition of tremie concrete. During the placing of the final concrete, the position of the tunnel is controlled from a steel gallows frame supported by H beam piles driven in the river bottom. When the section being lowered is in proper position, closure is made by pulling it up to the completed part of the tunnel with steamboat ratchets. Temporary watertightness is obtained by the embedding of the ⅜ in. shell plate into a rubber and hemp gasket and then tremieing the joint. Backfilling is then completed, the temporary bulkheads removed and permanent splices of the tunnel lining plates made by welding in the dry. The tunnel cross-section is circular in form, consisting of a steel shell 30 ft in diameter within which is placed a structural concrete ring 18 in. thick. Outside the steel shell there is a concrete protective covering, a minimum of 2 ft thick, giving the exterior of the tunnel section an octagonal form. The ⅜ in. steel shell is the watertight medium, the 18 in. reinforced concrete ring is the strength medium and the external concrete forming the octagon provides weight to overcome buoyancy

THE ventilation system of the new Bankhead tunnel, Mobile, Ala., represents a departure from previous practice in subaqueous vehicular tunnels. The comparatively short length of this tunnel, as well as the necessity of keeping first cost and upkeep low, made the conventional transverse distributive system unjustified. The Mobile portal is located in Government St. in the heart of the business district of the city, so that any plan which would involve discharging vitiated air from this portal was out of the question. High real estate costs, as well as the nature of the district, made a ventilation building in Mobile undesirable.

In the system used, fresh air is drawn into both portals and carried longitudinally to the midpoint of the tunnel. At this point the vitiated air is drawn through a series of ports into a duct below the tunnel roadway, whence it flows to the ventilation building on Blakely Island, and is exhausted to the atmosphere. In this way all ventilation equipment is concentrated at one point, and the building housing the equipment could be built over

the tunnel in the most advantageous position possible.

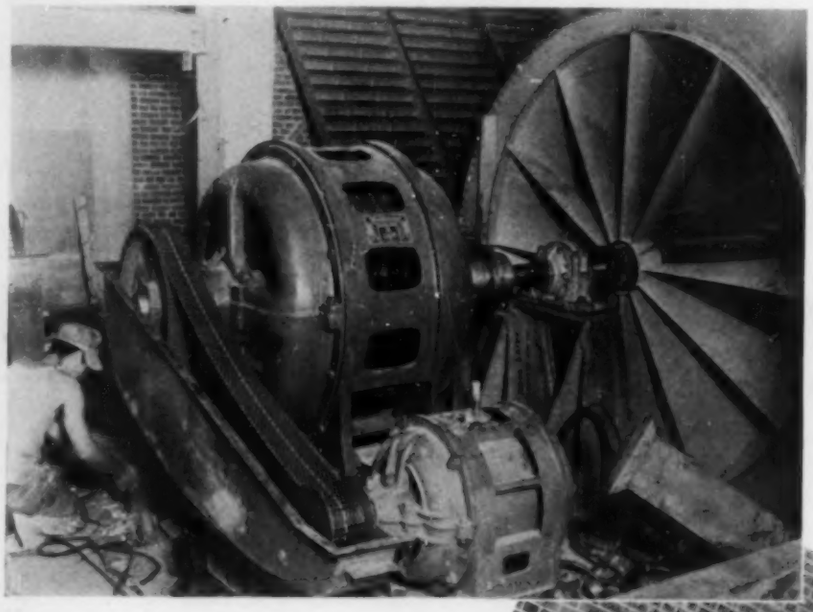
This system is not particularly sensitive to wind conditions or local differences in barometric pressure. Flow reversal or a static condition in the tunnel can occur only with a combination of minimum ventilation and extreme wind. Such a condition can, of course, be readily overcome by increasing the fan speed.

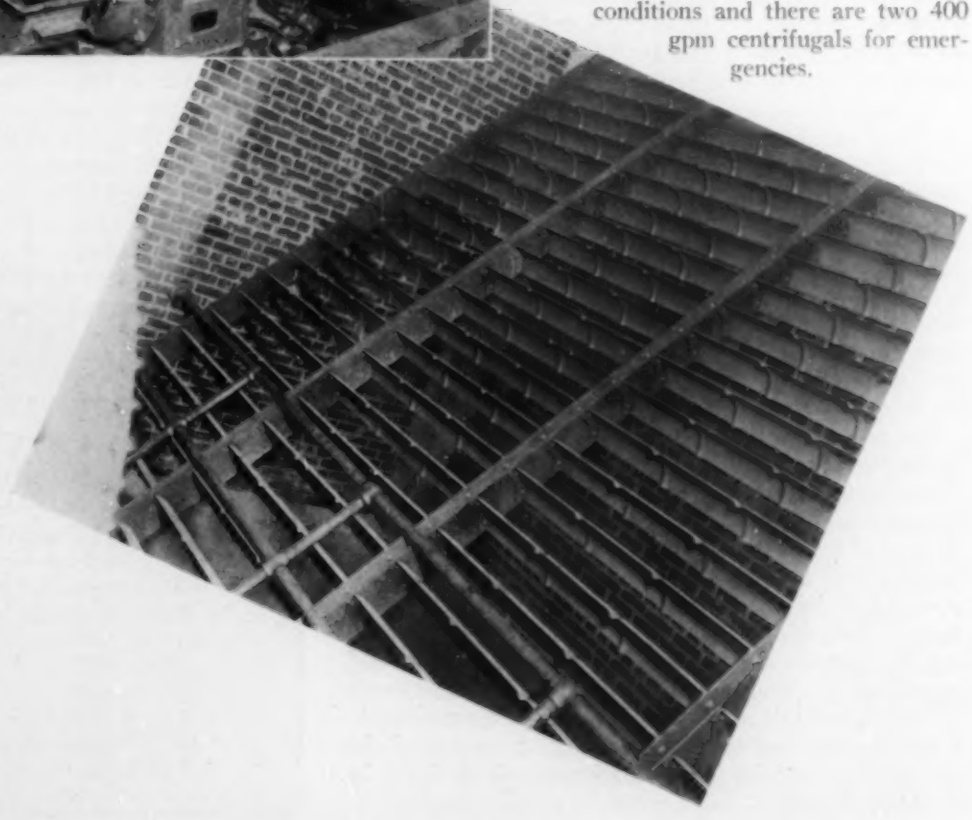
The elimination of the conventional upper air duct gives increased headroom and permits a 21 ft roadway with only 27 ft of internal tunnel diameter.

Vitiated air flows along the lower air duct to the ventilation building, at which point it divides, passing through two compound elbows to twin uptake stacks on either side of the tunnel. The uptakes lead to a plenum chamber comprising the larger part of the first floor of the ventilation building. In this plenum chamber are situated the three fans, which exhaust each to an individual evasé stack leading vertically upward to the atmosphere. The fan motors and drives are separated from the exhaust chamber by steel partitions, so that they are protected from the dust laden, vitiated air. The large entrance doors of the building and a removable panel in the exhaust plenum form, in effect, an air lock so that fans may be removed for repair without shutting down the tunnel ventilation. Each fan is provided with a leaf damper in the evasé stacks.

Tuned frequency motor control is employed to insure proper synchronism of switching operations with fan speed. The magneto used in connection with this control is gear driven from the end of the fan shaft and is also used to give continuous indication on the control board of the actual fan speed.

Three sumps provide for tunnel drainage. These are situated at the Mobile portal, the ventilation building on Blakely Island, and at mid-river. The Mobile portal sump is of unusual capacity to care for the heavy rainfall expected in this locality, a rate of 4 in. per hr having been used in the design; capacity allows storage for 45 min at this rate, exclusive of pump discharge. At the Blakely Island end of the tunnel a closed type of structure has been carried to the grade point and watertight hurricane gates provided to close the tunnel in case of an emergency arising due to high water. At the low point of the tunnel near mid-river, a sump and pump chamber are situated in the space under the tunnel roadway. In this pump chamber a triplex pump takes care of normal conditions and there are two 400 gpm centrifugals for emergencies.





Three fans are used, two of which will take care of maximum ventilation requirements, the third being available as a spare. They are double width, double inlet backwardly curved blade centrifugals having a wheel diameter of 91 in. At their maximum operating speed of 493.5 rpm two fans will deliver 269,500 cfm each, which corresponds to about 174 cfm of fresh air per linear foot of two lane roadway. For their high speed, the fans are direct connected to 14 pole, 350 hp, 440 volt squirrel cage motors. Two lower speeds are available, one at approximately ½ and one at about ¼ full speed. The two lower speeds are obtained by means of chain drives from two speed 1200/600 rpm, 40/10 hp induction motors. Fan bearings are of spherical roller type . . . Shop tests indicated that better performance could be secured by the use of turning vanes at the top of the uptakes leading to the fan rooms. These turning vanes (right) are made up of a series of short blades set in a frame at a 45 deg angle over the vertical inlet stacks

One of United Air Lines' Mainliners in flight

Heating and Ventilating Up in the Air

. . . . . involve specialized problems not met on terra firma, says W. W. Davies of United Air Lines

HEATING, ventilation and automatic temperature control, as applied to commercial air transportation, involve a number of specialized problems, due to the atmospheric pressure changes with changes in altitude, extreme humidity variations, speed, vibration, and rapid temperature fluctuations. These variations all result from the rapidity with which the airplane can move from one atmospheric mass to another.

Ventilation of Airplanes

General Ventilation—The ventilating system, as now used in most commercial transports for obtaining the desired amount of air in the cabin, depends entirely upon the "ram" effect obtained with a duct opening into the air stream (see cut-away view).

The present ventilation rate for one of the United Air Lines' Mainliner airplanes is approximately one complete air change per minute. Such a high rate is advisable in this application for several reasons. A large number of changes of moderately heated air guarantees better cabin temperature distribution. Tests have shown that, throughout the cabin, temperatures do not vary more than ± 3 F, with this high rate. One change per minute also permits a rapid removal of tobacco smoke and any odors. It is also possible with an air change every minute to maintain a pressure in the cabin approximately 1 in. of water higher than that existing outside of the airplane, thus eliminating infiltration of cold air from the outside.

This rate of one change per minute, in terms of individual passengers carried, is about 40 cfm.

Individual Ventilation—Also incorporated on all major transports at the present time are small, individually controlled, cool air ventilators situated in close proximity to the seats. The purpose of these is to provide a flow of cool air on the passenger's face if desired. This additional air is beneficial during hot weather or in the event a passenger desires a cooler temperature than that maintained for his fellow passengers.

Several important factors must be taken into consideration at the time of design of such units. The regulation of the pressure within the air duct or ventilator must be such that the flow of air to the passenger will be the

SUMMARY

Atmospheric pressure changes with changes in altitude, extreme humidity variations, speed, vibration and rapid temperature fluctuations—all resulting from the rapidity with which an airplane can move from one atmospheric mass to another—are factors which must be allowed for in the design and application of heating and ventilating equipment by the commercial air lines. W. W. Davies, Project Engineer, United Air Lines Transport Corp., briefly describes the heating and ventilating requirements of modern airplanes and recent developments in this field. A second article will cover the air conditioning of airplanes on the ground, and cabin supercharging

same with one or all of the individual ventilators opened; the individual ventilator and duct combination must be so designed that the noise level of this assembly is well below that of the cabin; and the adjustment of the ventilator must be so restricted that the flow of air can only be directed on the passenger using the ventilator.

Humidity—Fortunately, there is no real problem with respect to humidity. In the course of an investigation conducted by the United Air Lines' research staff, data obtained from government weather statistics evidenced that, on the average, relative humidity between 5000 and 15,000 ft altitude varies from 40 to 64 per cent. Readings taken with a sling psychrometer on several occasions in various seasons of the year closely agree with these data. The humidity in the cabin is generally from 5 to 6 per cent lower than that of the outside air, and when flying in saturated air the cabin humidity may be even lower. For normal operation, with the excéption of possible extreme conditions, relative humidity in a cabin is within the accepted 40 to 50 per cent limit.

It is interesting to note that calculations indicate that to increase the humidity 10 per cent, it would be necessary to carry 35 lb of water for a 4 hr trip, assuming standard air conditions at 10,000 ft. The weight of the water required (even neglecting the weight of suitable equipment for diffusing it in the cabin air) would make such an installation impractical for the few times it would be needed. The importance of weight in airline operation shows up as a vital factor, when it is realized that on the basis of one operator's study the value of 1 lb of added weight per airplane per year is something over $20.

Importance of Heating

There is probably no other condition in flight that is more aggravating to the passenger than the failure of the heating system. Such cases are definitely the exception. However, airline engineers must analyze such difficulties and recommend revisions to reduce the possibility of recurrences.

With the high ventilation rate of one change per minute, it is evident that the heating system must be of a large capacity. Numerous tests have shown that 150,000 Btu per hr is required to heat a Mainliner cabin to 75 F with an outside air temperature of 0 F, at a ventilation rate of one change per minute at 8000 ft altitude.

In general, three major types of heating systems have been used on commercial air transports, the hot air system, the steam system, and the liquid system. Another type now being considered is a self-contained unit which has a combustion chamber and fuel jet and burner combined. This unit uses a liquid fuel and also incorporates an auxiliary blower. It is similar in construction to one of the newer type automobile heaters.

Hot Air Heating System—The hot air system employs a shroud or manifold at the exhaust stack, the air being taken in at the front end of the shroud and carried back over the exhaust stack by means of ducts into a mixing valve. This valve is situated just ahead of the duct entry into the cabin. Cold air is also supplied to it by means of a scoop projecting into the air stream. The hot and cold air are mixed at this point by means of a manually controlled valve to give the desired cabin temperature.

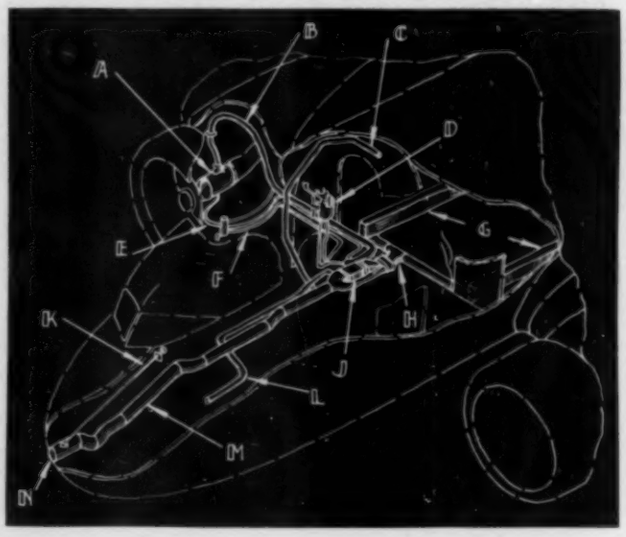
This is one of the simplest forms of heating systems and normally requires very little maintenance. With this arrangement care must be exercised in the design and maintenance to prevent leakage of carbon monoxide from the exhaust into the heated air. The possibility of exhaust gas leaking into the duct in the event of failure of the exhaust stack can be overcome by maintaining pressure in the shroud surrounding the stack higher than that within the stack itself. This then forces air into the stack, in the event of failure, and does not permit any of the engine exhaust gases to go into the cabin ventilating system.

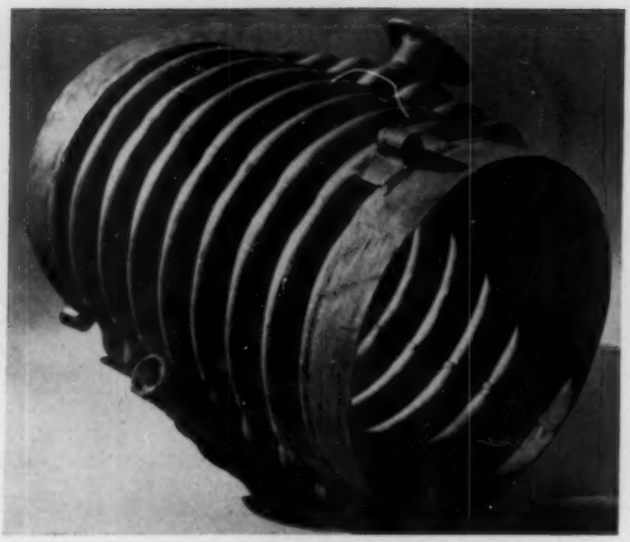
Steam Heating System—The steam heating system requires considerable attention both in operation and maintenance. However, it does eliminate any carbon monoxide hazard, and it has a high heat capacity.

A common design of steam heating system for aircraft is illustrated in the accompanying sketch. It incorporates a flash type boiler in the exhaust stack of the right hand engine, a steam radiator (condenser) under the floor of one of the cargo compartments and a reserve water tank with a pressure regulator valve. The system operates with only enough water circulating through the lower part of it to maintain steam pressure. Little or no water is carried in the boiler because as fast as the condensate flows to the boiler it is vaporized and passed through the large steam pipe to the radiator where it is recondensed and returned directly to the boiler.

The maintenance of a specific pressure in the steam system is controlled by means of a pressure regulator valve which is mounted on the top of the reserve water tank. The actual quantity of steam in the steam system is a function of the quantity of water in the lower part of the system. As additional water is allowed to flow from the reserve tank to the boiler, the steam pressure rises. Normally, the radiator will be condensing steam at a sufficient rate to furnish the proper quantity of water

Cut-away view showing ventilating and steam heating system on Douglas DC-3 transport plane. A—boiler in exhaust stack. B—steam line to radiator. C—cool air duct to individual ventilators. D—reserve water tank, pressure regulator and control valves. E—water line. F—drain and condensate lines. G—cabin heat ducts. H—mixing valve. J—radiator. K—nose valve control. L—cockpit heat duct. M—air supply duct. N—air entry in nose of plane supplying air by the ram effect





Flash type boiler used in airplane steam heating system. Feedwater entering the bottom flashes into steam almost immediately. As the action is a water quench, it is one of the severest treatments that can be given a metal. The temperature of the feedwater is about 200 F and the metal temperature reaches 1400 F

to the boiler to maintain the desired steam pressure. However, at the time this condensation rate is not high enough the pressure regulator valve (whose main purpose it is to maintain a satisfactory differential between the steam pressure above the boiler and that above the reserve tank) opens and permits more water to drop into the boiler, again raising the steam pressure to that desired. The reserve tank is mounted approximately 4 ft above the boiler so that there is a sufficient head of water to feed the boiler when necessary. The steam pressure in the lower part of the system actually balances the steam pressure in the top of the reserve tank plus the weight of the column of water.

Pressure regulators, relief valves and operating or control valves for such systems often need frequent adjustment, and in some cases the original units have required complete redesign. Probably boilers are the greatest source of trouble in the steam heating system. The boiler is substantially a flash type, the feedwater entering at the bottom and flashing into steam almost immediately. This action is a water quench and is one of the severest treatments that can be given to any metal. The severity is understood more readily when it is realized that the temperature of the feedwater is about 200 F, and the temperature of the boiler metal reaches approximately 1400 F. The metal is also stressed severely due to expansion and contraction each time the engine is run. Vibration characteristics also have a definite bearing on the type of design that can be used in boilers and have also been the principal reason for eliminating several types of design which otherwise proved satisfactory.

Liquid Heating System—The liquid heating systems for airplanes normally use ethylene glycol or some similar liquid. The design generally incorporates a heater in the exhaust stack which heats the liquid, the latter then passing through a radiator of standard design. In such a system, a controller or circulating pump must be incorporated to control the flow of the liquid to the stack heater. Such a system involves probable additional weight, as well as requiring considerable maintenance. Based on past experiences with such a system, it is doubtful if sufficient heat can be obtained under extreme atmospheric temperature conditions unless a large amount of solution is circulated rapidly.

Automatic Temperature Control

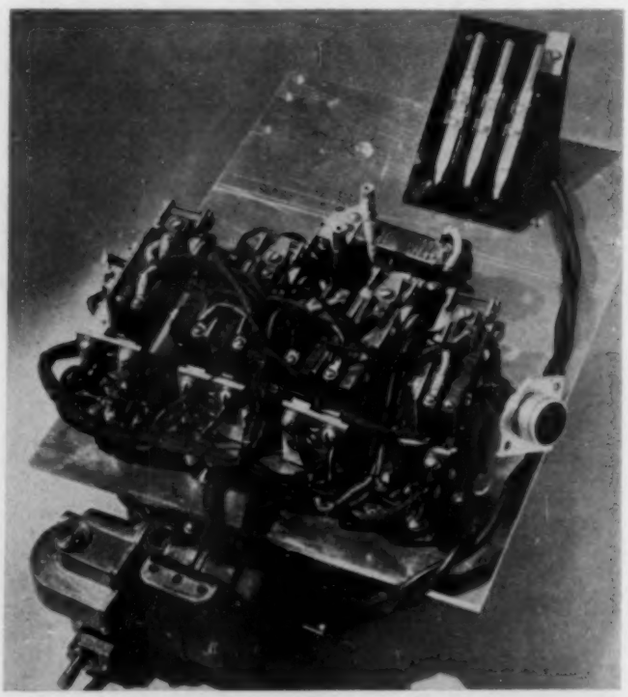
Experience has shown that automatic temperature control for any aircraft system is a much desired and needed feature. Controlling the mixing valve or damper which furnishes the tempered air to the cabin by means of an automatic control is easy to accomplish and gives desirable results. To avoid hunting or over-riding of the control, some form of proportioning or step-by-step control seems desirable. With such a system, when more hot or cold air is required to maintain the desired cabin temperature, the mixing valve moves progressively in small steps making minute increases or decreases in the cabin temperature as called for by the thermostat.

A recent development by the United Air Lines' research staff is an automatic temperature controller employing the mercury column type of temperature sensitive elements, and a thermal interrupter which incorporates a delay in the response of the mixing valve. This unit has proved very successful and is now in the final test stage.

The mercury column type of thermostat, properly designed, is found to be relatively sensitive and have a minimum amount of lag. Tests conducted have shown that a pressure loaded mercury column unit is not particularly subject to vibration in the order of the magnitudes as found in aircraft and when properly mounted offers no trouble from breakage.

[*A second article by Mr. Davies will cover air conditioning on the ground and cabin supercharging.*]

Automatic temperature control unit employing the mercury column type of temperature sensitive elements, and a thermal interrupter which incorporates a delay in the response of the mixing valve furnishing tempered air to the cabin. The unit shown is laboratory test equipment developed by United engineers



DAILY Degree Day Check Saves Heating Steam

R. E. Hieronymus*, General Superintendent, Aldis & Co., Explains How Check Is Made, What Results Have Been

SUMMARY—A study of 29 office buildings made last year showed that those which were checking their heating steam consumption daily on the degree day basis used 22 per cent less steam than buildings which were making no degree day check at all, and 17.5 per cent less steam than buildings making a degree day check on a monthly basis only. The importance of making such checks on a daily basis is therefore indicated by this study. . . . Mr. Hieronymus, general superintendent of a real estate and management company with many large buildings under its direction, described in December a method of making a daily check which is in wide use in Chicago. He gives here results achieved in an actual case—a building which is called the "Sample Building." In December, he explained the situation before the heating economy program was initiated. This month, he describes how the steam consumption was reduced 43 per cent. . . . Operating and management engineers not now making some sort of daily check will do well to heed the important message which Mr. Hieronymus presents

A STUDY of a group of office buildings made last year showed that those checking their heating performance *daily* on a degree day basis used 22 per cent less steam than those making no degree day check at all, and 17.5 per cent less steam than those making a check on a *monthly* basis only. The great value of a *daily* analysis is thus indicated.

A method of making such daily checks which is in popular use in Chicago is the Erlenborne chart. I described in the December HPAC how this chart is established for a particular building, and gave a resumé of the conditions existing in November, 1936, in an actual building before the heating economy program was instituted. This month, the same information for the month of November, 1939, is presented for this same building (which we call the "Sample Building" here) to show the extent of the improvement in steam consumption for heating, and in the average temperatures maintained in it.

*Member of HPAC's Board of Consulting and Contributing Editors.

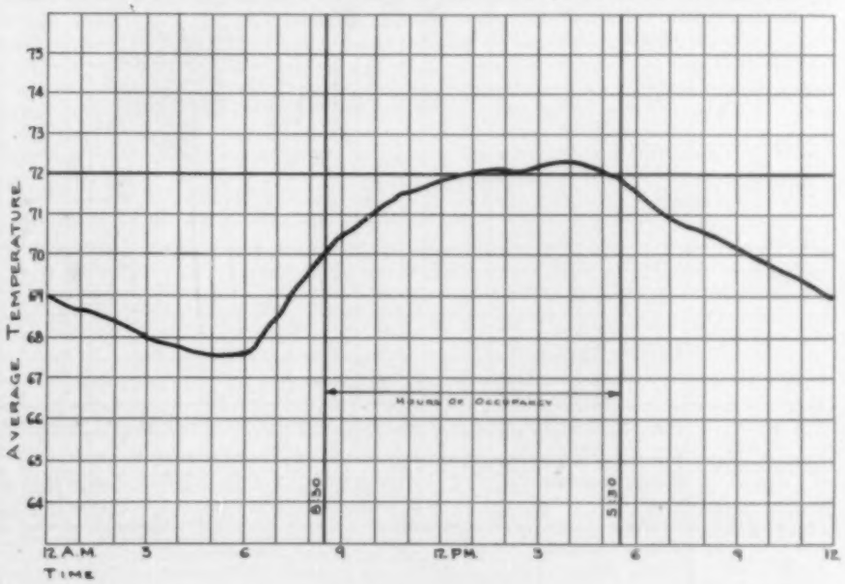
Tenant Complaints

As the steam consumption for heating the building was appreciably reduced, the management began to hear from some of the tenants—but this was not unduly discouraging. A log book was obtained in which was entered every heat complaint—its source, the time of day, special remarks about conditions, and (*important*) what disposition was made of it. It seems reasonable to expect that a few heat complaints are to be tolerated throughout the year—in fact, it is a healthy sign of "normalcy," for in the absence of any complaints at all it is certain that part if not all of the space is being greatly overheated, or that temperatures are being held down to tolerable limits by the unreasonable opening of windows.

In the initial development of the program the complaints were localized and most of them came from two or three locations. These were found to be "low spots" in the heating system and steps were therefore taken to increase the radiation, weatherstrip the windows, or to use other measures to make these spaces average instead of special as to heat requirements.

When the first two or three low spots had been brought up to standard, others came to light and during the succeeding months 15 or 20 such deficient premises were discovered and the heating facilities improved in them. Eventually a condition was reached where the occasional complaints were reasonably scattered throughout the building.

The average space temperatures in the building during the month of November, 1939. Note the altered character and generally lower level of the temperatures as compared with the graph for November, 1936, which was shown on p. 709 of the December article



STEAM OR FUEL CONSUMPTION CHART

For normal conditions turn heat on and off at:

BUILDING Sample MONTH OF Nov. 1939

Contents of Building 4,303,000 Cu.Ft. Degree-Days this month 725

On:	Off:	Steam or Fuel Allowance Pounds *	Mean Temp. °F
3:50	5:45	183851	-6
		180670	-5
4:00		178089	-4
		175508	-3
4:15		172927	-2
		170346	-1
4:30	5:30	167765	0
		165184	1
4:40		162603	2
		160022	3
4:45		157441	4
		154860	5
4:55		152279	6
		149698	7
5:00		147117	8
		144536	9
5:10	5:10	141955	10
		139374	11
5:15		136793	12
		134212	13
5:25		131631	14
		129050	15
5:35		126469	16
		123888	17
5:40		121307	18
		118726	19
5:50	4:45	116145	20
		113564	21
5:55		110983	22
		108402	23
6:05		105821	24
		103240	25
6:10		100659	26
		98078	27
6:20		95497	28
		92916	29
6:30	4:20	90335	30
		87754	31
6:35		85173	32
		82592	33
6:40		80011	34
		77430	35
6:45		74849	36
		72268	37
6:55		69687	38
		67106	39
7:05	4:00	64525	40
		61944	41
7:15		59363	42
		56782	43
7:25		54201	44
		51620	45
7:30		49039	46
		46458	47
7:40		43877	48
		41296	49
7:50	3:30	38715	50
		36134	51
7:55		33553	52
		30972	53
8:05		28391	54
		25810	55
8:10		23229	56
		20648	57
8:20		18067	58
		15486	59
8:30		12905	60
		10324	61
		7743	62
		5162	63
		2581	64
		0	65

Day of Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Day of Week					S							S							S				H			S				
Steam turned on at	6:40	6:25	6:45	6:40	9:00	6:15	7:25	6:40	7:25	7:05	6:30	9:00	6:15	7:30	7:40	7:50	7:55	7:25	8:30	6:15	6:50	6:45	9:00	6:15	6:45	9:00	6:00	6:40	6:40	7:00	
Steam turned off at	4:00	4:15	4:15	4:00	11:30A	3:45	3:45	4:10	4:00	3:45	4:00	12 N.	4:00	3:30	3:40	3:00	3:00	2:00	12:00	4:10	3:45	3:50	12:00	4:00	4:00	12:00	4:00	4:00	3:45	3:30	

Note: After Sundays and Holidays turn steam on 1 Hr. earlier than above.

Note: This chart based on .6 lb. steam * or ____ ____ fuel } per degree-day per 1000 cu. ft. of building volume.

STEAM RECORD:

Total pounds of heating steam consumed 1,573,653

Pounds of steam per degree-day 2170

Pounds of steam per degree-day per 1000 cu. ft. of building volume .504

FUEL RECORD:*

Total _____ of fuel consumed _____

_____ of fuel per degree-day _____

_____ of fuel per degree-day per 1000 cu. ft. of building volume _____

* (Insert unit which corresponds to fuel used, i. e. pounds, gallons, therms, or cubic feet.)

Below normal (blue)

Above normal (red)

{ A.M. in Red
{ P.M. in Black

There is no need for alarm in regard to complaints. If there are 240 tenants, for example, and during the year there are 240 well-scattered complaints, that may sound like a great deal of dissatisfaction—but it averages only one complaint per tenant per year, or only one complaint per day. This would probably still be a tolerable condition of affairs, but the efforts at economy were stopped far short of this number, good heating economy having been obtained. Three or four complaints per month in a building of average size probably are not too many.

The Results

Skipping the intermediate occurrences, the conditions and economy obtaining three years later are set out in the steam consumption chart for November, 1939, reproduced here and in the chart of average temperatures in the space for that month.

It is found that the steam consumption chart has a greatly different appearance from the one for November, 1936, published in my previous article. There is far less "red ink" and far more "blue"; the consumption on Sundays and the holiday is reduced to economical limits; and the steam consumption per degree day has been decreased from 3850 lb to 2170 lb, a reduction of 1680 lb or 43 per cent. This rate of reduction, if obtained for all the heating months and applied to a normal heating year of about 6300 degree days for Chicago, represents a decrease in annual steam consumption of approximately 10,584,000 lb, which improvement was actually realized in the case of the "Sample Building."

During this process there was no violent disturbance in the tenant relations, no loss of occupancy due to the curtailment of space temperatures, no extraordinary effort required of the building staff, and only relatively minor changes were made in the heating system or facilities so far as cost was concerned. These conditions of apparent adequacy and satisfaction after the improvement in economy testify that the change in operation was a reasonable one and bore no ill effect.

The loss from excessive heat is not always easily discernible. The steam enters the building through a closed pipe, or the fuel is delivered to the back door—perhaps at night. The heating steam rises through the building in closed pipes, is utilized in closed vessels (the radiators) and the waste leaves the building inconspicuously through open windows, by transmission through the walls and glass of the building, and by other leakage. A great deal of waste can take place without the management realizing it.

OPPOSITE

Steam consumption chart for the building for November, 1939, showing result of heating economy program. Note particularly the reduction of steam consumption on Sundays and holiday, the absence of any days of grossly excessive steam consumption and the preponderance of "blue" as against the "red." Note also that the steam consumption is 0.504 lb per degree day per 1000 cu ft, a reduction of 43 per cent from November, 1936

The main prospect of realizing this waste consists in determining what is being done elsewhere by well-run buildings and analyzing your own performance on some kind of a graphic chart basis. Particularly does the Erlenborne chart system described here recommend itself, for the waste in the processes it applies to truly stands out as so much "red ink."

Steam for Hot Water

Where steam is metered to the hot water heating apparatus, or where fuel is fired for heating water in a separate vessel, it should be deducted from the day's use and the chart kept for heating steam only. If it is troublesome or inaccurate to deduct the hot water steam, however, it is perfectly suitable to lump the whole thing and, for purposes of the daily check, to call it all heating steam. The rational use of the chart is not thereby affected and unless the hot water steam be an abnormally high proportion of the total steam requirement, it should make little noticeable difference in the application of the chart method.

Who Should Keep the Chart?

By all means, it is most essential that the chart be kept and the daily check be made not by the operating engineer himself but by the manager or a technical supervisor of the building. Even though the engineer starts out by using the chart conscientiously he should not be depended upon to get the most out of its use if he is solely responsible for it. Once the details of the chart and its use are worked out, it can be kept by a clerk or stenographer who may obtain the temperature and steam daily, fill in the chart and lay it on the manager's desk. The engineer should be encouraged to keep his own chart simultaneously with the one in the manager's office and to be well ahead of him on the scheduled improvement.

Importance of Daily Check-Up

Once the chart system has been put into use, each day's heating performance should be analyzed *on the day after*. If the analysis is not made until the end of the month there will be found a number of inefficient days, and after so long an interval the engineer can not possibly remember what happened to upset the program on those particular days. If, however, it is discovered on a Wednesday that a substantial amount of steam was wasted on Tuesday, the day before, the operating man can still remember in general what transpired that day and is in a position to take steps to do better.

Method Has Wide Application

It is apparent from examination of the fundamentals of this chart system that it can be used for any type of fuel whether it be steam metered in pounds, coal measured out by weight, oil utilized by the gallon, or gas purchased by the therm or by the cubic foot. Again, it will be realized that the system is applicable to any type of space heating, whether office building, factory, warehouse, hotel or apartment, for each has its own characteristics and suitable allowance can be made in the construction of the chart to take care of the peculiarities of each.

It is further suitable to use in any climate, for the whole process is reduced to a degree day basis and, within rather narrow limits, buildings of the same type are heated to approximately the same temperature no matter in what part of the country they are situated.

[*This is the second of two articles. The first was published in the December, 1940, HPAC.*]

SUMMARY—Difficulties encountered in obtaining carbon molybdenum steel pipe with satisfactory surface finish have led to incorporating new requirements in ASTM Specification A206-40T which are intended to govern the inspection of such pipe for surface defects. Practically identical requirements are being added to ASTM Specifications A106-40 and A158-40T . . . . These new requirements and the reasons for them are explained by Mr. Crocker, who was chairman of the subgroup which formulated them. Opinions pro and con are also presented. Both suppliers and users of such pipe will find this discussion to be timely and valuable

By Sabin Crocker*

SURFACE DEFECTS *in* Heavy Wall Pipe

DIFFICULTIES encountered in obtaining carbon molybdenum steel pipe with satisfactory surface finish have led to incorporating new requirements in the American Society for Testing Materials Specification A206-40T which are intended to govern the inspection of such pipe for surface defects. Practically identical requirements are being added to ASTM Specifications A106-40 and A158-40T. Heretofore the surface finish of pipe was governed in specifications only in general terms, such as:

"The finished pipe . . . shall have a workmanlike finish."

"Pipe showing moderate slivers may be machined or ground inside or outside to a depth which shall insure the removal of all included scale and slivers, provided the wall thickness is not reduced below the specified minimum wall thickness."

"The finished pipe shall be free from all immoderate slivers and depressions."

Obviously what comprises a "workmanlike finish" is open to question, as well as when a sliver is "moderate" or "immoderate." Other common sorts of surface blemishes akin to slivers but not mentioned by name in specifications heretofore are known in mill parlance as scabs, pits, seams, laps or tears. Beyond these there are mechanical scratches or abrasions known as cable marks, dinges, guide marks, roll marks, ball scratches and scores. Slightly enlarged photographs showing the distinctive appearance of some of these surface defects in heavy wall seamless pipe (carbon molybdenum steel) are presented in Figs. 1 to 4 through the courtesy of one of the large pipe manufacturers.

Fig. 1—Seam 0.02 in. deep on outside surface. Such a seam generally results from failure to completely eliminate a seam in the round before processing

"Fish Scale"

Further complications have come up lately in the occasional appearance of patches of fine crisscross cracks, laps and seams on the exterior—and sometimes on the interior—of heavy walled alloy pipe which have variously been termed fish scale, snake skin or alligator hide, depending upon the fancy of the narrator.

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The surface appearance of a patch of fish scale on the exterior surface of carbon molybdenum pipe is shown at a magnification of 10 diameters in the photomicrograph of Fig. 5. This view was taken on pipe in the as-rolled condition, but which had been pickled for the purpose of removing mill scale. Pickling, of course, serves to make cracks more apparent and thus aids in locating such patches on inspection. Fig. 6 is a photomicrograph of a transverse section of the pipe wall, again at a magnification of 10 diameters, which shows an edge view of these surface laps and cracks. Enlarged views of the defects of Fig. 6 are shown at a magnification of 100 diameters in Fig. 7. These cracks and seams penetrated into the pipe wall to a depth varying from 0.002 to 0.008 in., while the exterior surface was decarburized to a depth of about 0.010 in. as shown by the absence of black pearlite areas and, in this instance, by reduced grain size in this region. Decarburization to this extent probably must be expected as incidental to soaking billets in a furnace for a sufficient time to heat them up preparatory to rolling into pipe.

Bone of Contention

Whereas pipe mills have had little trouble in rolling light- to medium-wall carbon steel pipe with satisfactory surface finish, the greater tendency to blemishes with heavy wall pipe of either carbon or alloy steel has been a bone of contention between mill men and purchasers' inspectors for some time. Otherwise excellent pipe sometimes has considerable areas of fish scale or scattered instances of other surface defects which to the purchaser's inspector seem to call for outright rejection or at least removal by grinding. In the absence of any definite standards for guidance, the mill men can only conjecture in advance of inspection whether or not a particular batch of material will be acceptable to this or that customer. Furthermore the amount of rejections or corrective work ultimately called for, whether actually needed or not, may be so extensive as to constitute a large item of expense to the pipe mill which would have to be reflected in the price of the product. The ensuing arguments on this score as outlined below pointed the need for a more clear cut understanding about what could reasonably be done about surface defects.

Where defects are not defined, the inspector representing the purchaser either has to make his own decision or refer the matter back to those responsible in the home office. In either event decision has to be made on the basis of opinion rather than predetermined standards, and with little possibilty of obtaining uniform practice. Due to the hesitancy of inspectors in assuming responsibility for making decisions based wholly on opinion, they frequently have to refer such problems back to the home office, and the home office may in turn have to engage a consultant sufficiently versed in such matters to reach an intelligent decision. In any event a considerable amount of valuable time is consumed and at considerable expense, whereas with adequate instructions the inspector could have settled the matter on the spot in most cases.

In the absence of definite standards for surface defects, each consumer has to be an authority unto himself, and what is acceptable to one frequently will be unacceptable to another. Hence, where the manufacturer feels that a consumer's inspector is overly captious, he will be inclined to put material rejected for debatable surface defects back into stock to dispose of to the next comer. On the other hand, were surface defects defined, decisions would be more clean cut and rejected material should be scrapped as called for in Section 23 of ASTM A206 and companion specifications.

Fig. 2—Pits 0.03 in. deep on outside surface. Pits of this nature result from rolling in of mill scale during seamless mill processing

Definition of Surface Defects

Thus it developed that there was good reason for attempting a judicious definition of surface defects in heavy walled pipe with respect to when the pipe is acceptable as it is, when it should be rejected outright and when the manufacturer should be required (or permitted) to grind off or otherwise remove the blemishes.

Accordingly Subcommittee XXII of ASTM Committee A1 delegated the problem to a subgroup of its members, representative of all interests concerned, which was charged with surveying the problem and bringing in recommendations calculated to establish a satisfactory solution. This subgroup held a meeting at one of the principal pipe mills where actual specimens of pipe showing the various sorts of defects were examined and discussed with the mill men. The tentative standards for defining these choices as worked out for ASTM Specification A206-40T for carbon moly pipe were incorporated as follows in Section 20 of that specification. The *italicized* sentences were added in Paragraphs (a) and (b), while (c) was revamped completely to incorporate the new ideas.

Finish 20 (a). The finished pipe shall

Fig. 3—Shallow pits on inside surface which also result from rolling in of mill scale

Fig. 4—Light ball cut on inside surface (near top of photograph) produced by mill scale building up on the plug mandrel used inside the pipe during seamless mill processing

be reasonably straight and free from injurious defects, and shall have a workmanlike finish. *At the discretion of the inspector representing the purchaser, finished pipe shall be subject to rejection if surface defects acceptable under Paragraph (c) are not scattered, but appear over a large area in excess of what is considered "workmanlike finish."*

(b). Depth of Injurious Defects: *All defects shall be explored for depth.* When the depth of defects in the pipe encroaches on the minimum wall thickness (87.5 per cent of the nominal thickness), or is in excess of 12.5 per cent of the nominal wall thickness, such defects shall be considered injurious.

(c). Machining or Grinding Defects: Surface defects shall be classified and treated as follows:

1. U-bottom mechanical marks and abrasions[1] excepting pits, tears, scabs, slivers, etc., shall be acceptable without grinding or machining, if not deeper than 12½ per cent of the nominal wall thickness nor in any case deeper than $\frac{1}{16}$ in. All V-bottom marks and abrasions and U-bottom marks and abrasions deeper than $\frac{1}{16}$ in. but not deeper than 12½ per cent of the nominal wall thickness shall be removed by grinding or machining to sound metal. Where the width of any mark or abrasion is less than the depth it shall be classified as V-bottomed.

2. Pipe showing inside or outside surface checks (fish scale) $\frac{3}{64}$ in. or less in depth need not have these defects removed. Such defects over $\frac{3}{64}$ in. but not more than $\frac{5}{64}$ in. in depth shall be removed by machining or grinding. Pipe on which these defects are more than $\frac{5}{64}$ in. in depth shall be rejected, unless the manufacturer can demonstrate to the purchaser that the defects are not injurious as defined in Paragraph (b).

3. Pipe showing scabs, seams, laps, tears or slivers not deeper than 5 per cent of the nominal wall thickness need not have these defects removed. If deeper than 5 per cent such defects shall be removed by machining or grinding providing they are not injurious as defined in Paragraph (b).

4. Pits which do not fall under the classification of injurious defects as defined in Paragraph (b) need not be removed.

5. When grinding or machining is permitted, the outside diameter at the point of grinding or machining may be reduced by the amount so removed. Should it be impracticable to secure a direct measurement, the wall thickness at the point of grinding, or at a defect not required to be removed, shall be determined by deducting the amount removed in grinding, or the depth of the defect, from the minimum measured wall thickness at the ends of the pipe, and the remainder shall not be less than 87.5 per cent of the nominal wall thickness.

6. Machining or grinding shall follow the mill's inspection of the pipe as rolled and shall be followed by supplementary visual inspection.

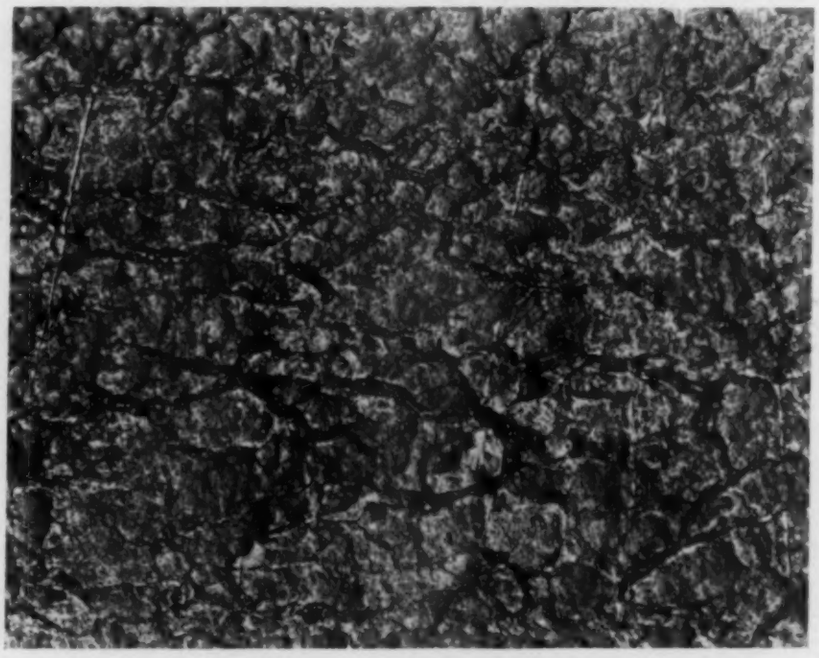
(d) (Note: There is no change in Paragraph (d) which pertains to repair of injurious defects by welding.)

Incidentally, according to these new finish requirements, all of the defects shown in Figs. 1 to 7 would be acceptable without grinding or machining if present in a pipe wall greater than about ½ in. in thickness, except that all V-bottomed marks or abrasions must be removed regardless of depth.

Opinions Pro and Con

The foregoing revisions were offered by the special subgroup as a tentative solution of the problem and were so accepted at the June meeting of the Society by Subcommittee XXII and Committee A1 for trial in Specification A206-40T, and in corresponding paragraphs of the 1940 versions of A106 and A158. In adopting these tentative limits on surface defects no one was prepared

Fig. 5—View of "fish scale" on outside surface of carbon molybdenum pipe, magnified 10 times



[1]Marks and abrasions are defined as cable marks, dinges, guide marks, roll marks, ball scratches, scores, etc.

Fig. 6—Transverse section of pipe wall showing edge view of surface laps and cracks known as "fish scale," magnified 10 times

to demonstrate conclusively when such a defect could be the locus from which an incipient failure might spread, or when it was purely of a superficial nature. Two of the opinions pro and con expressed by members of Subcommittee XXII are of interest in that they bring out both the merits and possible deficiencies of the scheme:

Favorable Opinion Expressed by Representative of Large Oil Company—"In reviewing these proposals, we felt that they would be a step in the right direction toward clarifying the present indefinite requirements, and that since the final word on the acceptance of defects rests with the purchaser's inspector, they should have the effect of tightening up on manufacturer's supervision. Experience will undoubtedly indicate subsequent revisions necessary to preclude the receipt of undesirable defects, but we believe the proposed wording for Paragraph 20 (a) limiting the allowable area of defect requirements and in Paragraph 20(b) that all defects be explored, permits the purchaser to judge final acceptability of pipe offered."

Adverse Opinion Expressed by Representative of a Leading Pipe Fabricator: "We wish to take objection to the suggested Paragraph 20(c) wherein defects are classified as U-bottom and V-bottom and it is to be specified that U-bottom mechanical marks of limited depth are acceptable.

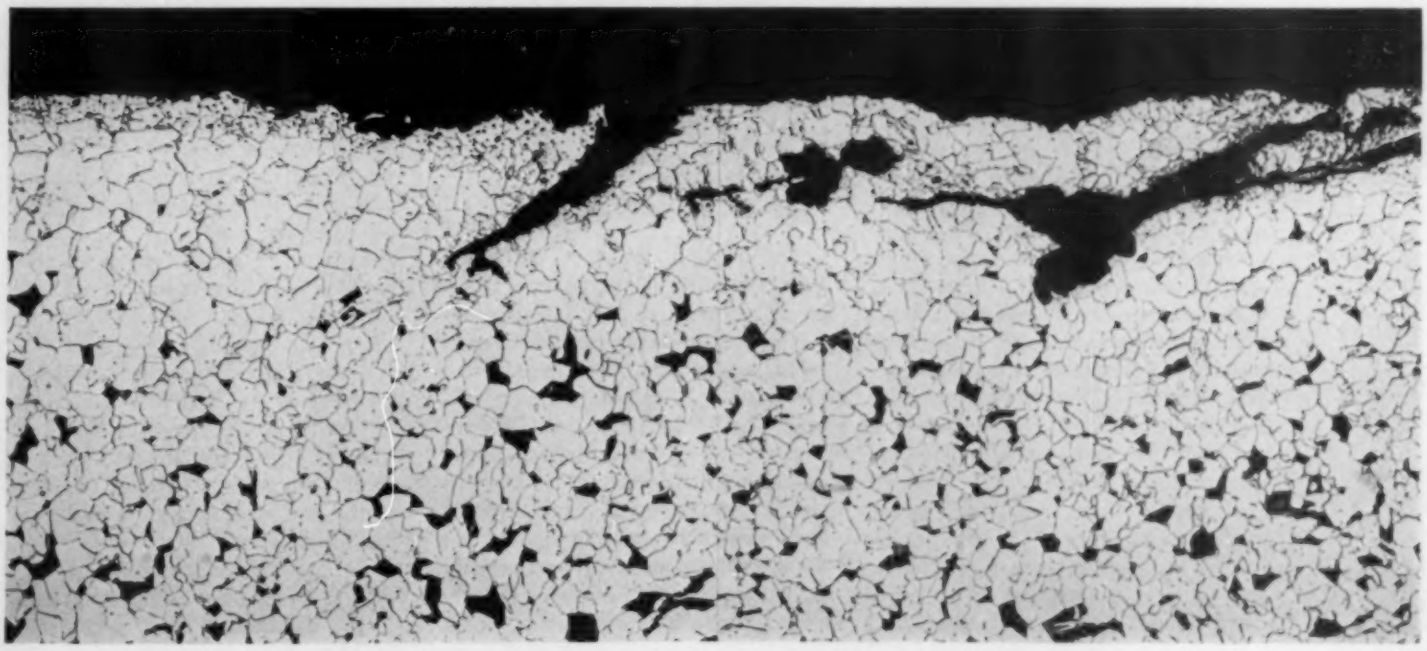
"Our experience cautions us against approving such a general statement. Cable marks, dinges, guide marks, roll marks, ball scratches, scores, pickle patterns, damaged ends, grip marks and numerous other mechanical defects of limited depth are unobjectionable only to a degree. *Carte blanche* approval of this condition will ultimately result in a loosening up of mill supervision. These defects can be eliminated by close supervision only and we feel that in specific cases these defects, while not exceeding the permissible depth of the specification, may be objectionable by reason of their number. The italicized portion of Paragraph 20(a) we feel to be only a palliative and not a cure for this objectionable condition.

"Sub-paragraph 3 of the proposed Paragraph 20(c), if permitted to remain in the amendment, would result in nicked seams, as the only gage of a seam depth is either grinding it out or nicking it to its depth at intermittent points along its length. One can appreciate that this would result in the shipment from time to time of seams of objectionable depth because of the fact that the seam may not have been nicked at its deepest point. We believe that any seam, regardless of its depth, should be filed or ground out to its elimination."

No Harm in Trying

It was the consensus of the committee, however, that the proposed limits are on the safe side and no harm could come from trying them. Furthermore, should these limits be found through trial to need revision, or should other defects become so prevalent as to need definition, then these tentative requirements can be altered to suit. With these ends in view it is hoped the new requirements will be favorably received by producers and consumers alike and tried out to determine their serviceability from all angles. In the letter ballot taken in Subcommittee XXII there was only one ballot cast against the new requirements on surface defects, which have since been approved by Committee A1 and the ASTM, and printed in the 1940 revisions to standards and tentative standards.

Fig. 7—Enlarged transverse section of pipe wall showing edge view of same surface laps and cracks as Fig. 6, but magnified 100 times. The actual depth of these cracks is 0.002 to 0.008 in.



Protecting Factories Against Attack

AIR conditioning of industrial plants is considered by the military as one of the best protections against attacks. Under total war conditions it is very probable that the military would require that many industrial plants making things for defense be air conditioned.

Air Conditioning

Air conditioning is considered a possible necessity by the military at this stage of preparations for war, chiefly in certain munitions plants. It should be borne in mind, however, that air conditioning as a specification rarely appears as yet in plans of the army or navy. The present policy in connection with industrial plants for national defense is to secure the plant and to bring it to the stage of production as swiftly as possible. The thought seems to be that the need for elaborate protective features of plants may be avoided by producing arms and equipment which will keep attackers away. That idea seems fundamental in the military mind.

As the matter stands at present, air conditioning and similar installations in defense plants are almost wholly at the discretion of the plant owner or plant operator. This principle applies to the plant that is built with government money as well as to the plant that is built with private funds. If it does not appear in the specifications imposed as fundamental by the government, the discretion lies with the builder or operator. At the same time it should be remembered that the government people heartily approve the plant people who put in air conditioning and similar equipment. They look with complete favor upon any action that will make production easier and make the workers more comfortable and happier. The military people feel that many industrialists will use air conditioning to sustain the morale of their workers, and to help the production of precision instruments and equipment. But it should be clearly understood that *the initiative for the installation of this air conditioning must come from the industrialists*. It is their problem. And by the same logic it is *the initiative of the air conditioning industry that will, to a large extent, determine how much equipment may be installed.*

What is generally in the minds of the people who make the plans in the quartermaster general's construction division may be gathered from the outline of minimum passive defense protection for plants drafted by the planning branch. They think plants should be situated with the protection of hillsides, and in broken

By Arnold Kruckman
Washington Correspondent

and wooded terrain, when feasible. They hold it is advisable, but not essential, to disperse the buildings to form an irregular pattern.

And here is where air conditioning would appeal to the industrialist. Army people feel that it would be wisdom to lay out the plant so black-outs would be feasible in an emergency. The plant with solid wall and roof construction, like the Allison aircraft engine plant at Indianapolis, described in the March HPAC, is considered an ideal. Artificial light and air conditioning is required at all times. The army people stress, however, that the Allison plant was built absolutely on the initiative of the corporation, and that it is solely inspired by the Allison people themselves.

Protective Features

The outline suggests dim blue lights, hooded, so the beams cannot be seen from above; it is intimated that white guide lines should mark curbs, walkways and entrances, and that double doors and entrance hallways should be provided. It may interest you to know that emphasis is laid on the declaration that complete protection of structures against direct hits by heavy bombs is not considered economically or militarily justifiable at this time. As protection against bomb splinters, it is suggested that window openings be kept as high as possible above the ground. Bomb fragments, it is said, are thrown at an angle of about 15 deg with the plane of impact. Firewalls are urged wherever they can be built. Provision also is suggested of places where, later, below-ground-level bombproof shelters may be built, *shelters with air conditioning.* Designs for standard shelters for 50 persons will be furnished by the quartermaster general's construction division. It is suggested they should be placed outside of the plant building but immediately adjacent and easily accessible from the inside. Eventually it is believed there should be storage space for spare parts and for key machines with protection against light bombs and splinters. Special concrete barriers are suggested at doors and entrances to prevent bomb splinters from flying through the openings.

Duplicate Piping

Two independent pipe lines for gas and water are urged. And two independent sources of power are recommended. All power and telephone lines are to be buried underground. Transformers and oil switches and similar outdoor electrical equipment are to be placed in subterranean vaults. And fuel oil and gasoline supply tanks are to be buried outside of buildings.

Concealment and camouflage is suggested. Army people declare light colored buildings are plain as a glowing light from the air on moonlight nights. To avoid this they use dark, light-absorbent shades in painting the buildings. And when the paint is applied in a mottled pattern, visibility is almost nil both day and night. However, colors vary with neighborhoods and with seasons. Again the army puts the problem in its final form up to the industrialist. It suggests that each plant is a problem to itself, and that each owner must study his own problem of camouflage as well as of air conditioning.

In general, landscaping is suggested with trees about the same height as the buildings.

Lights, Action, AIR CONDITIONING!

Motion Picture Industry—Like Many Others—Requires Lots of Air Conditioning for a Number of Services...

By Arthur J. Hess of English & Lauer

SUMMARY

In addition to the air conditioning requirements of administrative departments and the huge sound stages, motion picture studios require air conditioning also for the film processing plants or laboratories, and for film handling, including cutting. In film processing, controlled temperatures and humidities are important as they affect the rate of drying; of greater importance, however, is the maintenance of relative humidity at such a point as to prevent the building up of static electrical charges which might spark and set the film on fire. Filtration is even more important than humidity control, for specks of dust and dirt can cause imperfections both in the picture and the sound track; often, the air is triply filtered, and special methods of selecting air filters — and in some cases, special filtering media—must be used. . . . During the cutting process, control of humidity is the essential air conditioning function, together with maintenance of reasonable temperatures. . . . One studio, which has 16 huge stages, requires a total air supply of over a million cfm, has a peak demand of some 4000 tons of cooling, and is supplied by a chilled water circulating system with about four miles of piping installed in tunnels under the streets of the studio lot

FILM processing plants or film laboratories, as they are called, present altogether different problems than do the sound stages or the other departments of motion picture studios. In the first place, the conditions maintained are process conditions and not necessarily comfort conditions, and in the second place, air must be as clean as it is possible to get it.

How Film Is Developed

A brief non-technical explanation of the mechanics of film development will clarify the reasons for the air conditioning problems in laboratories. Laboratories have the dual job of developing the exposed films and making prints from these films for distribution to the exhibitors.

Developing and printing of motion picture films is a continuous process and is accomplished by guiding the moving strip of film through the various developing and wash solutions at a rate of from 50 to 150 fpm. The film is passed from the developing and washing process through cabinets, with very carefully controlled conditions for drying. These dryers are called "dry boxes" and the films pass through the boxes at the same rate as through the solutions. After drying, the film is reeled ready for projecting. It should also be noted that the sound is developed right on the film simultaneously with the developing of the picture. The sound appears as a wavy line of varying thickness, called the sound track, in a marginal space at the side of the film. Reproduction of sound is accomplished by projecting light through the sound track into a photo-electric cell. The variation in intensity of the light passing through the sound track can be converted back into the same sounds that were recorded by changing the varying light impulses into electrical impulses which are changed to sound and sent out through a loud speaker.

It is of interest to note that many times motion picture scenes are taken silently and the sound added later; this is called "dubbing in" and is usually done when the sound to be recorded consists of music of any type, so that the sound recording can be done under ideal acoustical conditions which probably do not exist where the scene is taken. It is also of interest that important musical renderings are usually recorded five or six

A skating rink set. The ice—and the air conditioning—are real, but the snow is not

times and the better parts of each rendering are pieced together to form a more perfect whole than any single rendition by the artist or artists.

Why Air Conditioning Is Needed

Temperature and humidity conditions directly affect the rate of drying of the film, which rate is very important since speed is essential and the faster the drying can be properly done, the greater the efficiency of the laboratory. However, the most important reason for humidity control lies in the fact that the high speed of the celluloid film over the rollers and guides will build up static electrical charges in excess quantities and at excess voltages, and this static electricity, if discharged through a spark, can set the film on fire. In humidities of about 60 per cent there are practically no static charges built up. Therefore, humidity control is very important as a fire and explosion prevention measure.

Filtration is even more important than humidity control in film process work, for any specks of dirt or dust deposited on the film while it is still wet during or after the process work will cause imperfections both in the picture and the sound track. Tiny imperfections on the film loom up large on the screen due to the high magnification. In fact, so small are some of the dust particles that the ASHVE ratings of filters cannot be used because the tiny particles which can cause so much trouble on the film are not usually considered as affecting comfort air conditioning and are evidently disregarded in standard filter efficiency ratings. A local, specialized method of selecting filters for such service has been developed for use in filter design for motion picture processing systems.

Permanent type oil filters of either the automatic or unit style can be used to remove the bulk of the dust and dirt. In a number of installations, pocket type filters with renewable cellulose media, selected to handle approximately one-half to two-thirds of the rated capacity, are used as a final step in filtration.

And even this media must be properly located by the designer to provide for an even distribution of air over the filter surface and proper maintenance must be assured by the plant operator. Crimped cellulose media have sometimes given trouble from the filter lint thrown off from the creases formed by crimping. One modern film laboratory in Hollywood filters the air introduced into the drying cabinets a third time, using a variation of the pocket type filter with coulemee cloth media. (Coulemee cloth is a type of felt with a hard surface on one side and a felted surface on the other.) However, this has been done principally because at this laboratory location there is on occasion a very fine silt dust suspended in the air which can sometimes pass through the first two filtrations.

A Modern Example

One of the new and modern laboratories is that of Warner Bros., in Burbank, Calif. It is one of the largest in the industry, having a daily capacity of upward of half a million feet of film a day. The laboratory is completely air conditioned with a plant having a cooling capacity of 125 tons of refrigeration and a heating capacity (using low pressure steam) of about 8000 sq ft of radiation. The cooling system uses circulating chilled water.

Air capacity of this plant is 70,000 cfm, which is all filtered through oil filters for the first filtration, and cellulose filters with twice the number of units recommended for ventilation for the second filtration. The air for the office section is taken off after the first filtration, the air for the laboratory spaces is taken after the second filtration, and the air for the dry boxes is filtered a third time just before this air is sent into the drying boxes. Recirculation is used for reasons of economy and cleanliness since there are few people in the space.

Humidity is controlled by means of dehumidifying spray chambers establishing the dew point; these chambers also do all the cooling. Low pressure steam coils are used for reheating so that all the air is forced through

the sprays and thus receives the advantage of any cleaning these sprays may do.

It is an interesting note that the control system is called upon to control temperatures of developing solutions to 1/10 of 1 deg.

Humidity Control for Film Handling

Air conditioning in film handling departments is very important, though actually control of humidity is the only essential function required.

Films are handled in storage spaces, during shooting, during processing and during cutting. Storage space conditioning is simple because it is not complicated by internal light and latent heat loads. The normal requirements are a consistently maintained relative humidity and reasonable temperatures.

The problems in the cutting room are, however, interesting. It is an assembly room for the picture, for it is in the cutting room that the various scenes are assembled into a complete picture of the proper length for exhibition.

We often wonder why motion pictures are frequently so different from the books from which the stories are taken. One of the principal reasons is that, though in most cases the whole story is filmed as written, the time required to exhibit such a story would be prohibitive and so it is necessary to cut out unnecessary parts (and many parts that are quite essential). The power of the cutter is very great since he is allowed considerable latitude as to which scenes and parts of scenes will be left in the picture.

During the cutting process the film is handled considerably and there is much cut and discarded film present, so the control of humidity with the resultant control of static electricity is very important.

Typical cutting rooms are constructed in an isolated building of completely fireproof construction. Film storage vaults are usually built in conjunction with the cutting rooms so that handling of film will be minimized. Cutting rooms are usually about 15 by 15 ft in size with a small projection room in connection. These rooms are constructed without windows and with underwriters' approved fire doors. These fire doors usually open directly to outside and where the cutting rooms are above ground floor level there are b a l c o n i e s. This makes it possible for any person in a cutting room in case of fire to step outside, close the fire door, and turn on the fire extinguishing system.

Air conditioning systems for cutting rooms follow ordinary rules of design but care must be taken to provide heavy automatic fire dampers for each opening. Where ducts pass through fire walls, means must be provided automatically to stop air handling equipment supplying and exhausting each room in case of fire.

An Air Conditioned Hollywood Studio

The 20th Century-Fox studio consists of about 16 huge stages together with an administration building, cutting rooms, camera building, machine shops, storage buildings, dressing rooms, restaurants and other buildings. The air supply systems have a total capacity of over one million cfm, not including small units.

The cooling system has an ordinary demand load of approximately 4000 tons of refrigeration which is handled by 1000 tons of installed capacity of centrifugal refrigeration machines in three units. These machines handle this large load because of a favorable diversity factor, together with two large chilled water storage tanks of 50,000 gal each for sudden large peaks.

Heating is by means of seven oil burning, low pressure, steam boilers in two plants. These boilers have a total capacity of 150,000 sq ft of radiation. The oil burners are of the rotary type and are fully automatic in operation. As a matter of fact, so well is this system designed that any one shift of the regular maintenance and operating crew for both cooling, heating and ventilating consists of only two men. This "lot" is about three-fourths of a square mile in area.

The heating system is a low pressure vacuum steam heating system with piping run in the same tunnels used for cooling piping.

The Metro-Goldwyn-Mayer lot has a similar system, the major difference being that, for the stages, the air is brought in at the top of the stages.

[This is the second of two articles by Mr. Hess on air conditioning in the motion picture industry. The first appeared in the October HPAC.]

A circulating chilled water system comprising some four miles of underground piping supplies the air conditioning equipment at the Fox studio from a central refrigeration plant. The 4000 ton demand load is handled by 1000 tons of installed capacity because of the favorable diversity factor and with the help of chilled water storage for large peaks

HORSEPOWER REQUIREMENTS of Refrigerating Compressors

William Goodman* Presents a Simple Method of Computing Total and Maximum Horsepower

FOR computing the theoretical horsepower required for refrigerating compressors, tables listing the horsepower per *cubic foot* of gas compressed have a number of advantages over tables listing the horsepower per *ton* such as have been widely used in the past. One of the principal advantages of the hp per cu ft values is that the total horsepower required for a compressor can be computed directly from its piston displacement without first computing its refrigerating capacity.

Second, such tables show clearly the little recognized fact that the horsepower of any compressor reaches some maximum value; it does not continue to increase steadily with increasing suction temperature, as many believe. Finally, the values of hp per cu ft are independent both of the subcooling of the liquid refrigerant ahead of the expansion valve and of the superheat of the refrigerant vapor entering the suction port of the compressor.

The advantages and the use of such tables—together with the table for "Freon-12"—were given in detail last month. In continuing the discussion this month, the table for ammonia is presented.

Superheated Suction Vapor

The values in the "Freon-12" and ammonia tables were computed from the tables[1] of the thermodynamic properties of these refrigerants on the assumption that the compression was isentropic. The assumption was also made that the vapor en-

*The Trane Co. Member of HPAC's Board of Consulting and Contributing Editors.
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[1]Thermodynamic Properties of Dichlorodifluoromethane (F12). American Society of Refrigerating Engineers, Circular No. 12. Thermodynamic Properties of Ammonia, U. S. Bureau of Standards, Circular No. 142.

Ammonia—Horsepower per cu ft of Vapor Compressed per Minute

Suction Temperature, F	Suction Pressure		Head Pressure, lb per sq in. Absolute										
	Lb Absolute	Lb Ga	150	160	170	180	190	200	210	220	230	240	250
			Head Pressure, lb per sq in. ga										
			135.3	145.3	155.3	165.3	175.3	185.3	195.3	205.3	215.3	225.3	235.3
			Saturation Temperature, F										
			78.8	82.6	86.3	89.8	93.1	96.3	99.4	102.4	105.3	108.1	110.8
-20	19.30	3.6	0.2163	0.2245	0.2325	0.2401	0.2473	0.2542	0.2609	0.2674	0.2735	0.2796	0.2854
-18	19.30	4.6	.2206	.2294	.2376	.2456	.2530	.2602	.2674	.2739	.2805	.2866	.2927
-16	20.34	5.6	.2251	.2342	.2429	.2510	.2588	.2664	.2737	.2806	.2876	.2940	.3002
-14	21.43	6.7	.2295	.2390	.2479	.2565	.2647	.2725	.2800	.2873	.2943	.3012	.3077
-12	22.56	7.9	.2336	.2434	.2528	.2616	.2704	.2784	.2862	.2935	.3011	.3083	.3150
-10	23.74	9.0	0.2377	0.2479	0.2575	0.2670	0.2758	0.2842	0.2924	0.3002	0.3078	0.3154	0.3224
-8	24.97	10.3	.2415	.2523	.2623	.2721	.2813	.2898	.2984	.3066	.3145	.3223	.3297
-6	26.26	11.6	.2454	.2565	.2668	.2772	.2867	.2956	.3044	.3130	.3213	.3293	.3369
-4	27.59	12.9	.2488	.2604	.2713	.2819	.2918	.3012	.3104	.3192	.3279	.3362	.3439
-2	28.98	14.3	.2526	.2645	.2758	.2867	.2971	.3070	.3166	.3255	.3346	.3431	.3512
0	30.42	15.7	0.2556	0.2678	0.2797	0.2914	0.3017	0.3120	0.3219	0.3314	0.3407	0.3493	0.3581
2	31.92	17.2	.2585	.2713	.2838	.2954	.3065	.3171	.3273	.3374	.3472	.3560	.3649
4	33.47	18.8	.2612	.2748	.2875	.2998	.3110	.3221	.3329	.3431	.3529	.3625	.3719
6	35.09	20.4	.2638	.2778	.2911	.3035	.3153	.3268	.3377	.3484	.3588	.3686	.3783
8	36.77	22.1	.2659	.2804	.2938	.3070	.3194	.3312	.3426	.3537	.3642	.3744	.3846
10	38.51	23.8	0.2681	0.2828	0.2967	0.3104	0.3232	0.3354	0.3475	0.3587	0.3700	0.3803	0.3907
12	40.31	25.6	.2692	.2848	.2989	.3131	.3265	.3394	.3515	.3633	.3751	.3858	.3964
14	42.18	27.5	.2706	.2868	.3015	.3160	.3300	.3432	.3557	.3681	.3805	.3917	.4025
16	44.12	29.4	.2715	.2880	.3034	.3185	.3328	.3468	.3596	.3725	.3850	.3968	.4081
18	46.13	31.4	.2725	.2894	.3051	.3207	.3353	.3499	.3637	.3767	.3897	.4015	.4134
20	48.21	33.5	0.2726	0.2897	0.3064	0.3225	0.3376	0.3524	0.3667	0.3804	0.3934	0.4062	0.4183
22	50.36	35.7	.2724	.2902	.3076	.3244	.3401	.3556	.3701	.3842	.3976	.4104	.4233
24	52.59	37.9	.2717	.2902	.3081	.3253	.3413	.3575	.3725	.3872	.4012	.4150	.4280
26	54.90	40.2	.2703	.2896	.3086	.3262	.3428	.3596	.3749	.3903	.4042	.4188	.4321
28	57.28	42.6	.2687	.2888	.3082	.3265	.3438	.3608	.3769	.3928	.4074	.4219	.4360
30	59.74	45.0	0.2664	0.2869	0.3074	0.3261	0.3441	0.3613	0.3779	0.3945	0.4096	0.4250	0.4391
32	62.29	47.6	.2639	.2852	.3062	.3253	.3443	.3620	.3792	.3961	.4118	.4271	.4424
34	64.91	50.2	.2613	.2831	.3046	.3248	.3439	.3625	.3803	.3972	.4143	.4295	.4455
36	67.63	52.9	.2575	.2798	.3020	.3227	.3426	.3619	.3801	.3976	.4146	.4312	.4477
38	70.43	55.7	.2525	.2767	.2995	.3206	.3412	.3605	.3794	.3983	.4155	.4325	.4492
40	73.32	58.6	0.2476	0.2727	0.2959	0.3183	0.3392	0.3593	0.3790	0.3979	0.4157	0.4336	0.4507
42	76.31	61.6	.2431	.2684	.2925	.3152	.3369	.3579	.3783	.3979	.4165	.4343	.4523
44	79.38	64.7	.2370	.2633	.2871	.3113	.3338	.3550	.3759	.3965	.4158	.4343	.4522
46	82.55	67.9	.2300	.2573	.2819	.3064	.3298	.3518	.3735	.3944	.4141	.4327	.4513
48	85.82	71.1	.2229	.2505	.2760	.3017	.3257	.3485	.3707	.3912	.4126	.4319	.4512
50	89.19	74.5	0.2148	0.2435	0.2700	0.2964	0.3209	0.3443	0.3667	0.3889	0.4102	0.4302	0.4496
52	92.66	78.0	.2057	.2347	.2622	.2896	.3141	.3385	.3624	.3848	.4069	.4276	.4478
54	96.23	81.5	.1964	.2264	.2549	.2826	.3080	.3334	.3572	.3804	.4036	.4251	.4450
56	99.91	85.2	.1860	.2171	.2459	.2746	.3010	.3265	.3520	.3761	.3991	.4208	.4424
58	103.70	89.0	.1746	.2060	.2366	.2656	.2929	.3194	.3450	.3697	.3939	.4160	.4385

Critical Compression Ratios and Constants for Determining Maximum Theoretical Horsepower for Various Values of k

k	Critical Compression Ratio $\frac{p_c}{p_s}$	Constant for Maximum Horsepower Z	k	Critical Compression Ratio $\frac{p_c}{p_s}$	Constant for Maximum Horsepower Z
1	2	3	1	2	3
1.00	2.718	0.001605	1.25	3.052	0.001788
1.01	2.731	.001614	1.26	3.065	.001794
1.02	2.745	.001621	1.27	3.079	.001801
1.03	2.760	.001629	1.28	3.091	.001807
1.04	2.772	.001637	1.29	3.104	.001814
1.05	2.786	0.001645	1.30	3.117	0.001820
1.06	2.800	.001652	1.31	3.130	.001827
1.07	2.813	.001660	1.32	3.143	.001833
1.08	2.826	.001667	1.33	3.156	.001839
1.09	2.840	.001675	1.34	3.169	.001845
1.10	2.853	0.001682	1.35	3.182	0.001851
1.11	2.866	.001690	1.36	3.195	.001858
1.12	2.880	.001697	1.37	3.208	.001863
1.13	2.893	.001705	1.38	3.221	.001870
1.14	2.906	.001712	1.39	3.234	.001876
1.15	2.920	0.001719	1.40	3.247	0.001882
1.16	2.933	.001725	1.41	3.260	.001887
1.17	2.947	.001733	1.42	3.273	.001893
1.18	2.960	.001740	1.43	3.285	.001899
1.19	2.973	.001747	1.44	3.298	.001905
1.20	2.986	0.001754	1.45	3.311	0.001911
1.21	2.999	.001760	1.46	3.324	.001916
1.22	3.012	.001767	1.47	3.337	.001922
1.23	3.026	.001774	1.48	3.349	.001928
1.24	3.039	.001781	1.49	3.362	.001933

SUMMARY—Computing the horsepower of compressors from tables of "horsepower per cubic foot" of refrigerant vapor circulated is much simpler than computing the horsepower from tables of "horsepower per ton" such as have been widely used heretofore. The use of tables of horsepower per cubic foot such as are presented in this article entirely divorces the power requirements of the compressor from its refrigerating capacity. The power required by a compressor depends only upon the compressor itself, whereas its refrigerating capacity depends on other factors external to the compressor. . . . Furthermore, this article clearly brings out the little-recognized fact that the horsepower of a compressor does not continue to increase steadily with an increase in suction temperature as many believe. There is one suction temperature at which the horsepower is a maximum. Above and below this one suction temperature the horsepower will be lower than the maximum. Formulas—and tables to simplify their use—are presented for computing the suction temperature at which the horsepower is a maximum and for computing the value of the maximum horsepower itself. . . . Altogether, this article presents a novel approach to the subject of computing the theoretical horsepower of compressors. This approach simplifies basic concepts and should prove useful and illuminating to many

tered the compressor in a saturated state. However, substantially the same values would have been obtained if the calculations had been based on superheated vapor entering the compressor. To check this point, a number of computations based on *superheated vapor* entering the compressor were also made from the data,[1] and the hp per cu ft was found to be almost identical for superheated vapor temperatures up to 100 F. This fact is further substantiated by Equation *b* of Footnote 2, which shows that the hp per cu ft depends only upon the initial and final pressures. Therefore, the total horsepower required by a compressor will be the same regardless of whether the suction vapor is saturated or superheated.

Critical Compression Ratio

As illustrated in Fig. 1 on p. 713 of the December article, the horsepower required for ammonia compressors generally rises with increasing suction temperatures in the range of evaporator temperatures for which ammonia has customarily been used. Because of this, the impression has been widespread that the horsepower of all compressors must always rise with increasing suction temperatures. This is far from being the case.

For carbon dioxide, for instance, the same graph shows that the horsepower falls with increasing suction temperatures for evaporator temperatures above approximately 5 F. For "Freon-12" in the usual range of evaporator temperatures for comfort cooling, the horsepower at first rises with increased suction temperatures, reaches some maximum, and then decreases for a further increase in suction temperature.

Symbols

hp_m = maximum theoretical hp required per cu ft of vapor compressed per minute.

k = ratio of the specific heats of the refrigerant.

p = suction pressure of vapor, lb per sq in. absolute.

p_c = condenser pressure, lb per sq in. absolute.

p_m = suction pressure for which the theoretical hp will be a maximum, lb per sq in. absolute.

v = specific volume of vapor at suction pressure, cu ft per lb.

W = work required to compress vapor adiabatically, ft-lb per lb of vapor.

w = work required to compress vapor adiabatically, ft-lb per cu ft of vapor.

Z = a constant (see table).

"Freon-12" compressors within the range in which they are ordinarily applied have a self-limiting horsepower characteristic—an important fact which is generally not recognized.

For any given refrigerant, the total horsepower required by a compressor depends upon the weight of refrigerant vapor compressed and the ratio of the absolute pressures in the condenser and the evaporator. As the suction pressure rises, the density of the refrigerant increases. Hence, because the volume of vapor circulated by the compressor is practically constant, a g r e a t e r weight of refrigerant is compressed and the horsepower tends to increase with increasing suction pressures. On the other hand, this tendency is offset by the fact that with increasing suction pressures, the compression ratio decreases, which tends to decrease the horsepower required by the compressor. Depending upon which of these two tendencies predominates, the total horsepower required by a compressor may either increase or decrease with increasing suction pressures.

The critical compression ratio—which may be defined as the ratio of the absolute head pressure to the absolute suction pressure at which the theoretical horsepower is a max-

imum—can be found by means of the following equation[2]:

$$\frac{p_c}{p_m} = k^{\frac{k}{k-1}}$$

The values in column 2 of the table of critical compression ratios and constants given here were computed by means of the above equation. If the value of k, the ratio of the specific heats for the refrigerant is known, the critical compression ratio can be found in this table.

The following example illustrates the use of the table of critical compression ratios and constants.

Example: Find the suction gage pressure and temperature at which the horsepower required for an ammonia compressor will be a maximum if the head pressure is 185.3 lb ga. Assume $k = 1.29$.

Solution:

$p_c = 185.3 + 14.7$
$= 200$ lb per sq in. absolute

From column 2 of the table, for $k = 1.29$,

$$\frac{p_c}{p_m} = 3.104$$

$$p_m = \frac{200}{3.104}$$

$= 64.4$ lb per sq in. absolute, the suction pressure at which horsepower is a maximum.

Gage pressure at which horsepower is a maximum $= 64.4 - 14.7 = 49.7$ lb per sq in. ga.

The evaporator temperature corresponding to this pressure is 33.6 F from tables of the properties of ammonia. For suction temperatures above and below this value, the horsepower will decrease.

[2]This equation is derived as follows:
The following equation for the work required to compress a perfect gas adiabatically is sufficiently accurate for most vapors. This equation can be found in any text book on thermodynamics.

$$W = 144 \frac{k}{k-1} p v \left[\left(\frac{p_c}{p} \right)^{\frac{k-1}{k}} - 1 \right] \ldots [a]$$

Work per cubic foot of vapor compressed is

$$\frac{W}{v} = \frac{k}{k-1} p \left[\left(\frac{p_c}{p} \right)^{\frac{k-1}{k}} - 1 \right] \ldots [b]$$

To find the value of the suction pressure for which the work per cubic foot is a maximum, equation b is differentiated with respect to p, yielding

$$\frac{dw}{dp} = \frac{144}{k-1} \left(\frac{p_c}{p} \right)^{\frac{k-1}{k}} - 144 \frac{k}{k-1} \ldots [c]$$

where $w = \frac{W}{v}$ = work in ft-lb per cu ft of vapor compressed per min.

To find the value of the suction pressure for which the work per cubic foot is a maximum, equation c is equated to zero. After clearing and substituting p_m for p, the following is obtained.

$$\left(\frac{p_c}{p_m} \right)^{\frac{k-1}{k}} = k \text{ or } \frac{p_c}{p_m} = k^{\frac{k}{k-1}} \ldots [d]$$

This is the equation given in the text.

Maximum Horsepower

The maximum theoretical hp per cu ft of compressor displacement can be computed by means of a relatively simple equation. This equation is[3]:

$$hp_m = \frac{144}{33{,}000} \frac{p_c}{k^{\frac{k}{k-1}}}$$

Letting

$$Z = \frac{144}{33{,}000} \frac{1}{k^{\frac{k}{k-1}}}$$

the preceding equation reduces to

$$hp_m = Z\, p_c$$

Values of the constant Z are tabulated in column 3 of the table of critical compression ratios and constants.

The following example illustrates the use of the foregoing equation and the constant Z.

Example: Find the maximum theoretical hp per cu ft required for the conditions of the preceding example.

Solution: From column 3 of the table, for $k = 1.29$, $Z = 0.001814$.

Using the equation $hp_m = Z\, p_c$,

$hp_m = 0.001814 \times 200$
$= 0.3628$ hp per cu ft per min, the theoretical maximum horsepower.

[3]Following is the derivation of this equation:
To find the value of the maximum hp per cu ft, equation d of Footnote 2 is substituted into equation b of the same footnote. After clearing the resulting equation this substitution yields,

$$w = \frac{144\, p_c}{k^{\frac{k}{k-1}}} \ldots [a]$$

or

$$hp_m = \frac{144}{33{,}000} \frac{p_c}{k^{\frac{k}{k-1}}} \ldots [b]$$

This is the equation given in the text.

Reports Progress in Revising the Code for Pressure Piping

New Edition To Be Ready for Distribution Later This Year, Says Chairman Ricketts*

FOR the past two years Sectional Committee B31 of the American Standards Association has been actively engaged in completely revising the Code for Pressure Piping, which was first published in 1935.

The range of the power section of the new code has been extended to 1500 lb per sq in. and 1000 F. While this steam pressure is considerably less than that found in several existing plants it was the opinion of the committee that practice had not sufficiently crystallized at this time to justify definite code provisions beyond these values.

The conflict of jurisdiction between the ASME boiler code and the power piping section covering piping between the boiler and the second valve has been resolved by both committees adopting substantially identical provisions for this piping. The two committees have adopted the same S values for calculating pipe wall thickness and have approved the use in that connection of the Lamé formula as an alternate to the Barlow formula where the nominal pipe size is 4 in. or greater and the minimum thickness is equal to or greater than 10 per cent of the inside diameter.

The scope of the gas and air section of the piping code has been extended to cover oxygen and hydrogen.

A new section has been added covering refrigeration piping.

The welding section of the code has been completely rewritten by a joint group of this committee and the American Welding Society.

At the annual meeting of the main committee held in New York December 5, the editing committee reported that practically all the work of editing the various chapters of the code had been completed and that the code should be in the hands of committee members for letter ballot in about two months.

The prospects seem good for having the new code in the hands of the public by late summer or early fall.

[Editor's Note—An analysis and description of the new code is planned for publication in HEATING, PIPING AND AIR CONDITIONING in midsummer.]

*E. B. Ricketts, who prepared this statement, is chairman of the Sectional Committee on the Code for Pressure Piping. He is connected with the Consolidated Edison Co. of New York, Inc., and last month was elected a vice-president of the American Society of Mechanical Engineers.

SMOKE Gets in Your Eyes

. . . . . and everywhere else if boilers aren't installed and operated properly. But opinions on proper setting heights differ. The test reported here indicates that some smoke ordinances are apparently quite conservative

THE primary purpose of a series of smoke determinations and efficiency tests made at New York University recently was to determine the suitability of the installation to burn a high volatile coal under varying operating conditions without producing smoke of a density which would be prohibited by city or other ordinances. The question is of general importance, so that it is felt the following report will be of wide interest. The tests were made by M. G. Ireland and C. A. Kuester, Engineers.

In addition to recording smoke density, it was considered desirable under the circumstances to determine the efficiency of the boiler and stoker, and to observe the performance of the boiler at ratings above normal.

The boiler is set 61¼ in. from the stoker deadplate to the bottom of the boiler tubes at the uptake end; this is 22¾ in. lower than the minimum requirements of at least one city's division of smoke regulation. The stack, of brick construction, has a height of 90 ft above grate, 80 ft above boiler damper and 20 ft above the building. Its area is 5.6 sq ft.

Since it was the intent to operate under commercial rather than laboratory conditions, the regular fireman was permitted to adjust the stoker air setting and control the fuel bed without advice or supervision from the engineers conducting the test. The only specific requirement was to have the fuel bed on the stoker at the same thickness at the end of the test as it was at the beginning.

Due to the inability of the building heating system to demand sufficient steam from the boiler, it was necessary to bleed steam to the atmosphere from an auxiliary 4 in. line connected to the main steam header, which resulted in the necessity of feeding make-up water to the boiler.

The coal supplied for this investigation was selected because of its relatively high volatile content.

Results of Tests

The graph shows the effect of excess air on smoke density. It is obvious from the curve that the smoke density increases as the excess air is reduced, and that the density increases rapidly with an excess air less than about 35 per cent. Under normal operating conditions the smoke density was very low, and was increased only by deliberate faulty operation of the stoker.

Relative density of smoke was determined by visual determination with the Ringelmann smoke chart. The chart was placed 50 ft from the observer in line with the stack

When air was reduced sufficiently to cause appreciable smoke, raw coal built up on the grate. The increased fuel bed thickness further reduced the air flow through the fuel bed and resulted in reduced steam output. This condition could not exist in practical operation.

The lowest readings are indicated as Ringelmann No. ½. At times during the test the smoke was, in the opinion of the observer, of a lighter density than this number (½). However, in view of the factors which can influence smoke readings, such as color of background, thickness of smoke stream and personal opinion of the observer, readings were recorded on the heavy side.

Part of the test results covering the performance of the boiler and stoker are given in Table 1. The data were determined from the average of 15 min readings taken over a period of 2 hr. Continuous observation was made of smoke density.

The proximate analysis was determined by laboratory test, while the ultimate analysis as fired was assumed, except for sulphur and ash, by using data for similar coals published by the U. S. Bureau of Mines.

Discussion of Results

The test results show an efficiency of 82.5 per cent at a rating of approximately 144 per cent and the heat balance calculations indicated that this efficiency is correct. The efficiency test was incidental and not the primary objective of the tests. Efficiency tests should be of at least 8 hr duration to level out inaccuracies due to water level in the drum, coal level on the grate, and to average other readings.

The test rating of 144 per cent was limited by the inability of the

Effect of excess air on smoke density

heating system and the temporary 4 in. bleeder pipe to relieve the boiler of any greater output. It is believed that a higher rating could very easily have been attained had facilities to relieve the steam been available.

The stoker performed in a very satisfactory manner. Stoker performance is a very essential part of the smoke problem, and without proper stoker design, smokeless combustion may be impossible regardless of furnace or boiler designs. Conversely, the constant improvement in stoker design allows smokeless combustion with lower setting heights. The trend toward smaller combustion space due to improved fuel burning equipment is particularly evident in the power boiler field, where heat release rates up to 80,000 Btu per cu ft have been employed without undue smoke.

The test conditions exceeded the expected normal conditions in the following respects:

Rating of the boiler during the test was approximately 144 per cent, exceeding the usual allowance by 24 per cent.

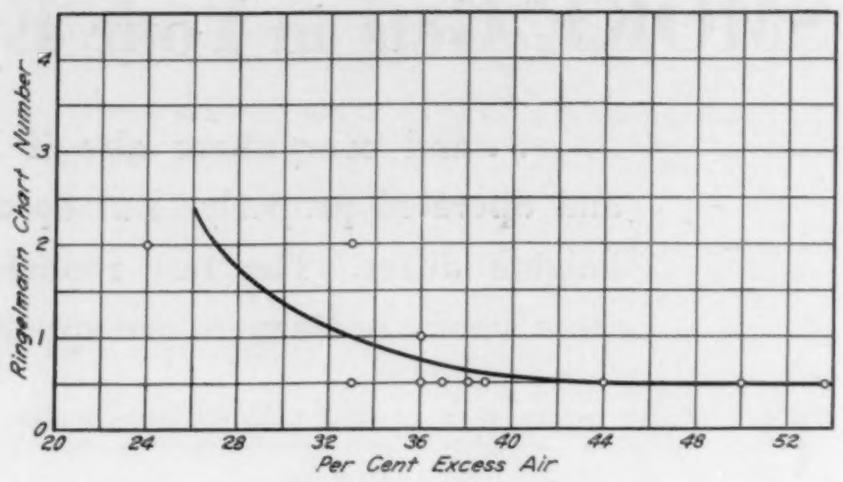


Table 1—Partial Test Results

Type of test	Continuous operation
Type of stoker	Single retort underfeed
Maximum feed rate of stoker, lb per hr.	800
Feed rate setting, lb per hr	600
Type of boiler	Longitudinal drum, water tube
Commercial rating of boiler, sq ft radiation	21,730
Heating surface of boiler, sq ft	1,552
Furnace volume, cu ft	163
Hearth or grate dimensions	width 5 ft 6½ in., length 6 ft 6½ in.
Hearth or grate area, sq ft	36.3
FUEL	
Bituminous Coal—Sewald Seam—Baldwin Mine—Randolph County, W. Va.	
Size	65 per cent above ½ in.
PROXIMATE ANALYSIS, AS FIRED	
Moisture, per cent	1.49
Volatile matter, per cent	29.27
Fixed carbon, per cent	63.70
Ash, per cent	5.54
Calorific value, as fired, Btu per lb	14,416
ULTIMATE ANALYSIS, AS FIRED	
Carbon (assumed), per cent	80.94
Hydrogen (assumed), per cent	5.23
Oxygen (assumed), per cent	6.17
Nitrogen (assumed), per cent	1.40
Sulphur, per cent	0.72
Ash, per cent	5.54
DRAFTS AND PRESSURES	
Draft in furnace, in. water	0.072
Draft at boiler outlet, in. water	0.17
FLUE GASES	
Carbon dioxide, per cent	12.5
Oxygen, per cent	6.76
Carbon monoxide, per cent	0.0
Nitrogen (by difference), per cent	80.74
Temperature of flue gases leaving boiler, F	439
Dry flue gas per lb of fuel, as fired, lb	15.86
Excess air, per cent	46.5
Temperature of air for combustion (average), F	75
HOURLY RATES	
Fuel fired (average), lb	633
Combustion rate (average), lb	620.4
Heat release rate (average), Btu per hr	8,943,000
Unit combustion rate (average), lb per sq ft of hearth area per hr	17.1
Unit heat release rate (average), Btu per cu ft furnace volume per hr	54,860
Total corrected evaporation, lb per hr	6,932
Output, Btu per hr	7,528,000
Output, sq ft steam radiation	31,370
Heat absorbed by boiler heating surface, Btu per sq ft per hr	4,850
Corrected evaporation per lb of fuel as fired, lb	11
HEAT BALANCE	
Efficiency of boiler and stoker, per cent	82.50
Heat carried away by steam in flue gases, per cent	4.10
Heat carried away by dry flue gases, per cent	9.62
Heat lost by not burning carbon monoxide, per cent	...
Heat lost by not burning combustible in ash, per cent	2.12
Heat lost due to radiation, per cent	0.41
Unaccounted for, per cent	1.25

Note—Only a part of the test results are given above, taken from the report of the testing engineers.

Volatile matter of coal was approximately 30 per cent, which is considerably above the average volatile of coals available in many districts.

Setting height of boiler is 10¾ in. less than the requirements of at least one city ordinance for the so-called "compact" type of unit, and 22¾ in. lower than the "locomotive firebox" type boiler.

Furnace walls are completely water cooled, resulting in a very cold furnace. Calculated temperature is 1740 F.

Stack height and cross-sectional area is less than some code requirements.

The boiler is set 61¼ in. from the stoker deadplate to the bottom of the boiler tubes at the uptake end

[Illustrations courtesy of International Boiler Works Co.]

INDUSTRIAL HEALTH DEFENSE

How Plant Engineers Can Make Field Measurements of Industrial Ventilation

W. C. L. Hemeon, Engineer with Massachusetts Division of Occupational Hygiene, Describes Methods for Plant Use

ONE of the industrial problems presented by our preparations for national defense is that of potential hazards to the health and efficiency of workers caused by manufacturing processes and which can be corrected or alleviated by plant ventilation systems. The Air Hygiene Foundation pointed out recently that not only will many new hazards be introduced, such as those associated with munitions manufacture for example, but many of the usual conditions will become doubly dangerous when workers are over-exposed as a result of greatly increased plant output, overtime and pressure of work.

Development of industrial ventilation standards well deserves the increased attention being given it; this article is a plea for the coöperation of plant engineers in the good work, and a "how-to-do-it" explanation of useful instruments and methods.

Data of a fundamental nature, such as the characteristics of air flow at exhaust hoods, must be obtained under accurately controlled conditions in the laboratory, but it is a mistake for anyone to imagine that all the desired information will be produced from laboratory studies. The ventilation requirements of specific industrial processes must be determined for the most part by field studies. The most productive studies of this sort are, of course, those that pertain to processes recurring commonly in industry, for conclusions reached on the basis of studies of a few are applicable to all like processes.

We have, for example, reliable ventilation standards for rock drilling, granite cutting, trichlorethylene degreasing, garages and vehicular tunnels, spray painting, miscellaneous solvent-consuming processes and sandblasting, together with many relating to the control of nuisance dusts like that from woodworking machinery, grinding and polishing wheels. Most of these standards were derived—or the validity of laboratory studies were checked—by studies in the field. It is highly desirable that the list be extended, and therefore all engineers who can should participate in such work as opportunities arise.

What Must Be Known?

We need to know three things about an industrial ventilation system to describe it fully: (1) Does it adequately control the hazard? (2) What is the rate of ventilation? (3) What is the nature—shape and location—of the exhaust inlets or hoods? Engineers who publish industrial ventilation data should describe not only these factors but also the fundamental characteristics of the process—nature of air disturbance, absolute quantity of contaminant created, and so on.

SUMMARY—Development of industrial ventilation standards well deserves the increased attention being given it, particularly as our preparations for national defense mean the introduction of new hazards to employee health and efficiency, and because existing hazards become doubly dangerous under the stress of increased output. . . . . While data of a fundamental nature on industrial ventilation must come from laboratory studies, it is a mistake to assume that what is needed can be 100 per cent provided by researchers. Industrial plant engineers must determine much of the required data by means of field studies. . . . . How to make such plant or field studies is the principal subject of this discussion. In some cases, the educated senses of sight and smell are excellent methods of determining the adequacy of a ventilating system. Usually, however, instruments and devices of one kind or another are required. . . . . Among them are chemical smoke producers, such as that illustrated in Fig. 1, the use of which is explained in the text. The ordinary glass U-tube water gage is very useful and versatile, especially when equipped as shown in Fig. 2. The pitot tube and inclined draft gage, especially with the proper accessory equipment, Figs. 3 and 4, are reliable instruments. Finally, it is highly desirable to have a means of closing the test hole in a duct after the readings have been taken. For that purpose, the closure illustrated in Fig. 5 has been devised

Your Nose Knows

To answer the first question, the services of the chemist-industrial hygienist are usually necessary. But there are many processes where the educated senses of sight and smell provide almost as good a criterion for judging the adequacy of a ventilating system; processes like pickling that generate acid vapors, rock crushing processes that generate large quantities of visible dust, and processes generating such irritants as caustic soda spray, formaldehyde, etc., are examples.

Chemical Smoke Producers

In other cases, chemical smoke producers are of value, particularly when the exact source of contamination is known to be limited to a definite area and no visible fume or dust is generated by the process itself. Use of such a device permits one to observe the air currents induced by the exhaust and thus to determine to what extent the positively induced air currents cover the known zone of contamination.

Of the devices available for this purpose, the smoke tube designed by the U. S. Bureau of Mines is most convenient for industrial purposes; this device, with slight modifications, is illustrated in Fig. 1. The

smoke producing chemical is a liquid—anhydrous tin tetrachloride—which forms a dense white smoke when air, with its normal content of moisture, is blown through it. Titanium tetrachloride may also be used.

A glass tube is filled with granular pumice which serves as a suspending medium for the liquid. A nozzle at each end projects a short distance into the chamber, forming a trap that prevents excess liquid from draining out into the ends when carried in a vertical position. A wad of glass wool at each end holds the pumice inside. Since the liquid is strongly corrosive of rubber or cork, it is desirable to have end plugs or caps of such form that they can be readily replaced as needed. We use a short length of rubber tubing with a small cork in one end.

Air is forced through the liquid saturated pumice by means of a common rubber aspirator bulb equipped with valves. Once saturated with liquid, a charge will last several weeks, depending upon frequency of usage, and plenty of warning of exhaustion is given by decreased intensity of the generated cloud. Recharging is the work of but a minute, and is effected by pouring through one end a fresh quantity of liquid until the pumice is visibly saturated.

If in using the smoke tube, the action of an exhaust hood is observed to induce positive air currents at all points of the critical zone and to direct them uninterruptedly toward the hood, it is often possible to conclude that control is adequate. If the test indicates that the exhaust does not "reach" all parts of the zone, an air analysis will usually be necessary to resolve the doubt.

U-Tube Manometer

The ordinary glass U-tube water gage is very useful and versatile. We can estimate the flow rate of air into an exhaust opening by measuring suction in the pipe right after the inlet; we can measure friction loss in special pieces of equipment and the velocity pressure at points of discharge from fans, etc., if it is great enough, and thus estimate total air flow.

In making a hole in the duct wall for measuring static pressure, almost everyone knows that it should never be punched by driving a nail or other sharp point, since the jagged edge formed on the inside distorts the air currents and is certain to result in an inaccurate reading. The hole should be drilled; the size of drill is of no great importance, although drills from $\frac{1}{8}$ to $\frac{1}{16}$ in. are the usual limits.

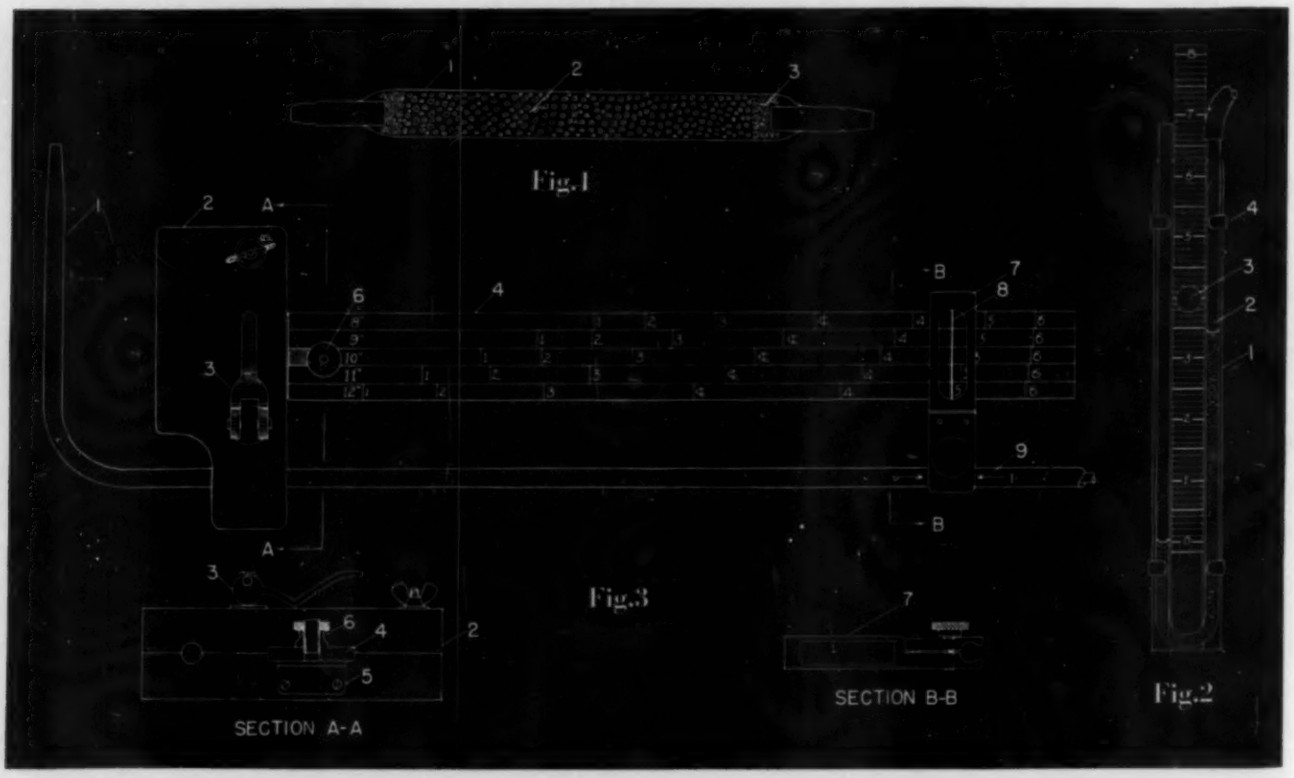
What is perhaps less appreciated is that even in *drilling* holes a burr or curl of metal may remain attached to the inner surface of the duct adjacent to the hole and sometimes cause incorrect readings. It has been noted in a dust exhaust system at least once that two readings taken a few months apart differed by an appreciable amount. The cause was found to be in an adhering metal curl or burr that was removed in the interim by the abrasive action of the dust.

Such burrs are easily removed at the time of drilling by a little extra manipulation of the drill. After it

Fig. 1—Smoke tube used in field ventilation studies. A rubber aspirator bulb attached to one end forces air through the pumice saturated with anhydrous tin tetrachloride. 1—Glass tube with end nozzles (about 10 in. over-all). 2—Granular pumice, saturated with anhydrous tin tetrachloride. 3—Glass wool

Fig. 2—U-tube manometer with movable scale made from wooden slide rule. 1—Wood slide rule. 2—Glass tube. 3—The thumb knob. 4 — The spring clips

Fig. 3—Pipe traverse scaling device for pitot tube enabling rapid and positive positioning of tube in all sizes of ducts. 1—Pitot tube. 2—Split cleat guide. 3—Quick action clamp. 4 — Scale No. 1. (4 in.—12 in.) 5—Angle with stud bolt for anchoring scale. 6—Thumb nut. 7—Reference line frame. 8—Reference line. 9—Engraved location for Scale 1



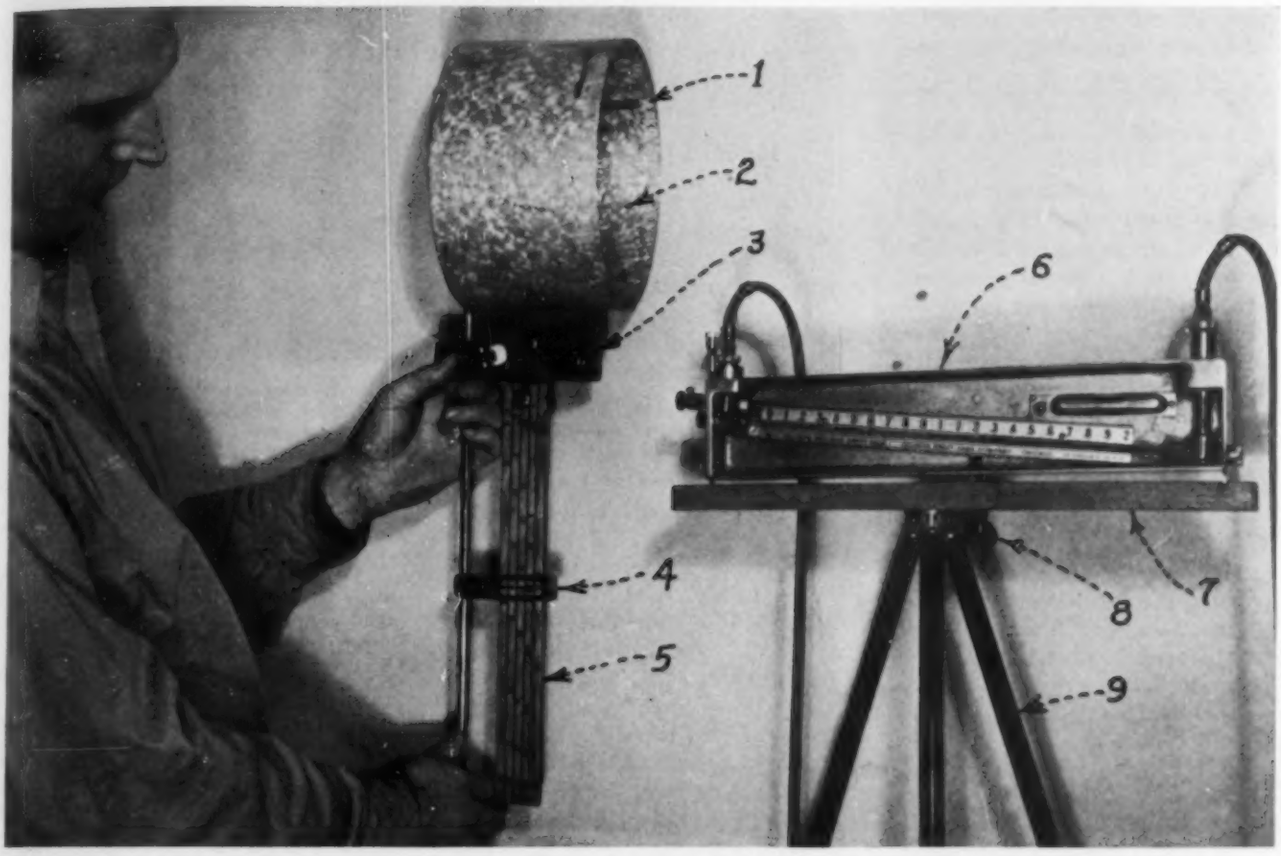


Fig. 4—Use of pitot tube with traverse scaling device. Wooden guide is held snugly against outside of duct. At right is inclined gage. 1—Tip of pitot tube positioned for third traverse point. 2—Demonstration pipe. 3—Split cleat guide. 4—Scale reference line. 5—Scale No. 1. 6—Inclined gage. 7—Platform for gage. 8—Wing nut and hook anchoring gage to the platform. 9—The collapsible tripod

has penetrated the duct wall the drill is held at an angle to the original axis and rotated conically. This treatment will effectively remove any adhering curls of metal. It is well always to drill two or three holes around the circumference of the duct in order to insure a representative reading, and if all readings are of the same order of magnitude but differing a little, they should be averaged.

When a U-tube is used a great deal there is an advantage in one having an adjustable scale. In reading the scale on the ordinary U-tube, one must note the scale reading opposite the lower water leg and subtract from or add to the reading opposite the higher water leg. With the device illustrated in Fig. 2, that mental step is eliminated.

A cheap wooden slide rule of the 25 cent variety is adapted for the purpose. The original markings are removed by sanding and the moving slide re-marked in inches and tenths. (First apply a coat of shellac, then when dry mark the scale with India ink. Applying a little talcum powder to the shellac surface makes the ink "take" better. Finish with another coat of shellac.) A thumb knob fastened to the center of the movable slide enables the instrument to be held in one hand while the position of the slide is shifted with the thumb of the same hand. In use the scale is shifted to bring the zero mark (or nearest even inch mark) opposite the lower water leg, whereby the net height of water is read directly opposite the higher level.

The glass tubing is anchored to the backing by strips of spring brass.

Pitot Tube

For measuring air flow accurately a universally reliable instrument is the pitot tube. It has wide application in laboratory studies but is rarely used in the field for measurements of factory exhaust systems for several reasons. In the first place, it is often impossible to find a long enough run of straight pipe to make a single center line reading a reliable measure of average velocity. This being the case, reliable results are obtained only by making a traverse of the duct with the pitot tube, and such a procedure involves reasonably exact locating of the tube tip at definite distances from the wall of the duct. A 12 point traverse requires six readings across the pipe diameter, then another six across a diameter at right angles to the first —the proper distances depending of course on the diameter of the pipe. The time consumed and the nuisance of computing these distances in the field is considerable.

Having computed them, the problem then is to fix the location of the tube as planned, always at right angles to the duct with the bent end parallel to the direction of air flow in two planes and always at the correct distance from the duct wall—all this for each of six readings on a single diameter.

Added to these difficulties is the problem of setting up the pressure measuring gage. The ordinary U-tube is not sufficiently accurate for measuring the pressures usually encountered and hence an inclined

gage that multiplies the reading by five or 10 must be used. Such gages must be read in a perfectly level position and a bench, table or even a box are ordinarily the least available objects when needed.

From these considerations, it is easy to understand why the pitot tube isn't commonly used for field measurements. The simple accessory equipment for the pitot tube and the inclined gage described below effectively eliminate these objections and inconveniences. With them, an accurate determination of air velocities in industrial exhaust systems may be made rapidly and conveniently.

Pitot Tube Accessories

The pitot tube is equipped with a sliding guide in the shape of a split cleat that can be clamped at any position along the length of the tube as illustrated in Fig. 3. With the tip of the tube inside the duct, the guide is held snugly against the outside surface of the duct, thereby maintaining the tube at right angles to the axis of the duct with the tip inside at a fixed distance from the duct wall. This is shown in Fig. 4.

We prepared a series of scales, one for each size pipe of a whole number of inches from 4 in. in diameter to 25 in., each indicating the six proper distances (along the diameter of the particular size pipe) from tip location to wall of the duct. There are scales for nine consecutive pipe sizes on each strip. The strip shown in Figs. 3 and 4 covers sizes from 4 to 12 in., inclusive.

The strip containing the proper scale for the duct at hand is coupled at one end to the sliding guide and rides through a brass frame, the wire in which constitutes a reference line for the markings of the scale.

Each of the nine scales on one strip employs the same reference line position, there being a separate position for the reference frame for each of the three scale groups. These are permanently engraved on the barrel of the tube.

Having fixed the reference line frame in position and coupled the proper scale in position—with the cleat guide and scale assembly parallel with the axis of the bent end of the tube—it is ready for use. The tube is then successively positioned at Stations 1 to 6 as rapidly as the gage can be read. All six readings can be taken in less than a minute when an assistant is available to record readings.

Inclined Gage Support

Of equal importance is an adequate support for the inclined gage; we use a tripod combination for this purpose. A collapsible metal tripod of a type sold in photographic supply stores is light and when collapsed requires little space. A strip of hardwood equipped with a brass fitting, adapted to thread onto the stud of the tripod, provides a platform which carries a tension hook serving as anchorage for the inclined gage itself (See Fig. 4). A commercial portable draft gage—shown in Fig. 4—is used that is admirably fitted for these purposes. After the gage is anchored to the tripod platform, it is brought to an approximate level by adjusting the position of the tripod legs. The final levelling is accomplished with the device accompanying the gage, bearing on the tripod platform.

With this arrangement, it is possible for an individual to make complete observations with the pitot without assistance if the location of the test hole is not so high above the floor or ground level as to make it difficult to read the gage. With an assistant, one can almost as readily make readings on a ladder many feet above the ground with tubing long enough to reach from the instrument to the test hole.

A test hole needs to be about ½ in. in diameter when the pitot tube has the usual curved elbow in order to permit positioning the tube tip close enough to the nearest wall for the first reading of the traverse. Such a hole is easily made with a tin knocker's square reamer, first making a small hole (⅛ in.) with a twist drill. A reamer fitted with a handle is compact and may be used satisfactorily on light gage metal. However, a plain reamer mounted in a bit brace is indispensable for the heavy gage metal (20 ga and heavier) usually encountered.

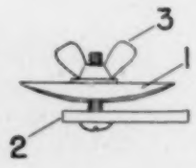


Fig. 5—Hole closure for holes in round ducts. 1—The galvanized iron disc (bent). 2—Metal lug and bolt. 3—Wing nut (with washer)

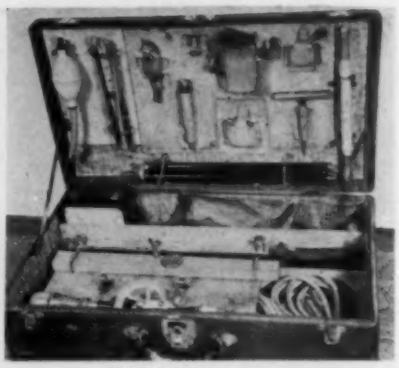


Fig. 6—Home-made carrying case for ventilation measuring instruments, containing aspirator bulb and U-tube, at left (on cover), tin knocker's reamer and smoke tube at right, tripod, inclined gage and platform, drill, bit brace and other needed miscellaneous equipment

It is highly desirable to have a means of closing the test hole after completion of tests, if for no other reason than psychological. For that purpose, the closure illustrated in Fig. 5 has been devised. It comprises a short bolt with a lug on one end and wing nut on the other, with a disc of galvanized iron between. The disc is bent into an arc of smaller radius than the duct, the lug end inserted in the hole and the wing nut tightened until pressure on the disc forces it to the contour of the duct. It presents a neat appearance and may readily be removed for subsequent tests.

Direct reading velocity meters of the swinging vane type are useful for quick estimation of low air velocities as in spray booths or at doorway openings into rooms that house exhaust systems. In fact, frequently such a measurement, by permitting approximate measurement of the volume of air supply to a room, provides a satisfactory means of checking total air flow.

A carrying case for the miscellaneous equipment used in field measurements is highly desirable and for maximum usefulness should provide for an ordered disposition of all articles therein. Our case is illustrated in Fig. 6. It utilizes spring clips, spring tension holders, leather pockets, wood compartments and hinged panels for securing the various items.

[Acknowledgment is made of the work of James Fuller, who constructed much of the special equipment described herein.]

Coördination Is Vital

. . . . . in installing good air conditioning systems, says J. M. Sperzel of Buensod-Stacey Organization

SUMMARY—Few owners and not too many designers realize the problems solved by air conditioning contractors in properly installing a carefully designed system. In this quick review, J. M. Sperzel of the staff of Buensod-Stacey Air Conditioning, Inc., points out some of them and the importance of careful coördination between engineering and construction. . . . . This organization has been responsible for the installation of many outstanding jobs, so Mr. Sperzel's remarks have a most practical background. . . . . He covers this month — among other things—drawings, permits, material orders, steel location, conflict with other trades, regulating elevation of work, hoisting equipment into place, and installation of major items of equipment

IF GOOD air conditioning is to be installed by the contractor, his erecting engineer must be able to visualize a complete picture of the finished building. The primary concern of the engineer is erection detail, which if neglected may produce poor results despite effort expended in careful planning. However, the temptation to believe that the building is constructed for the sole purpose of containing air conditioning must be resisted. Experience teaches that neglect of other working trades creates costly problems of interference, the solution of which through hasty and forced decisions affects performance of the system detrimentally.

Completion of satisfactory engineering drawings of the air conditioning system while the steel framework of the building is being erected establishes an opportunity to procure necessary approval of equipment from the engineer or architect. Approvals and permits required from authorities having jurisdiction must be secured to avoid unexpected construction delays, or expensive changes at a later date when acceptance by the owner is withheld because of code violations.

Material Orders

When approvals are obtained, too much emphasis cannot be placed on the desirability of transmitting immediate and well defined orders for materials to various manufacturers. An orderly delivery schedule, arranged to conform with the construction schedule of the builder and the specific erection requirements of the system, is of particular importance.

Nothing can so thoroughly disrupt a well planned erection program as a missing piece of equipment that is stranded in a freight yard at Squeedunk, or for which the manufacturer failed properly to interpret the order and is now putting through the mill. All promises to expedite delivery and apologies for delay only intensify the irritation when extra men hired to assist in the operation are standing idle, and the builder threatens to wall up the one hole in the structure through which the vital part can safely pass.

In an attempt to avoid the inconvenience of delayed deliveries, it is natural to accumulate equipment before it is ready for final placement. This necessitates frequent rehandling at inopportune times. The real solution to the problem lies in

Regulating elevation of work from the finished floor by a measurement from the underside of the arch above is a fast, easy means of maintaining runs within the space allotted. Where space is limited, measurements should be verified from bench marks. Sometimes, the undersides of steel beams are covered by a heavier thickness of concrete fireproofing than originally planned, causing trouble

having a delivery schedule for all equipment, systematically checking its progress with each manufacturer well in advance of the delivery date.

When the Flag Is Raised

About the time steel workers raise the flag to signify their work is accomplished, and while cement masons prepare a mixture for the arch of the first floor, it behooves the engineer to climb aboard the carpenter's forms with his sheet metal and pipe fitter foremen to see that the location of steel is in accordance with framing plans. If all is in order, sleeves are set to permit vertical passage of pipes and ducts, and inserts placed to anchor hangers for horizontal distributing mains. When methods of support utilize a trapeze hanger, show interest in the work of the electrician, who perhaps is setting mudboxes directly between the inserts. Later a lighting fixture may attempt to protrude through a beautiful run of sheet metal. If some one is wrong the opportunity is present to discover the error. Unfortunately, the electrician is right at times.

The plumber may be engaged in setting cumbersome fittings for roof and soil lines. Examine their locations carefully with respect to sheet metal runs. As plumbing lines must pitch toward a definite point, do not block the path or it may later be necessary to re-route the duct. Remember, air may flow uphill but water cannot. The decision will probably be in the plumber's favor.

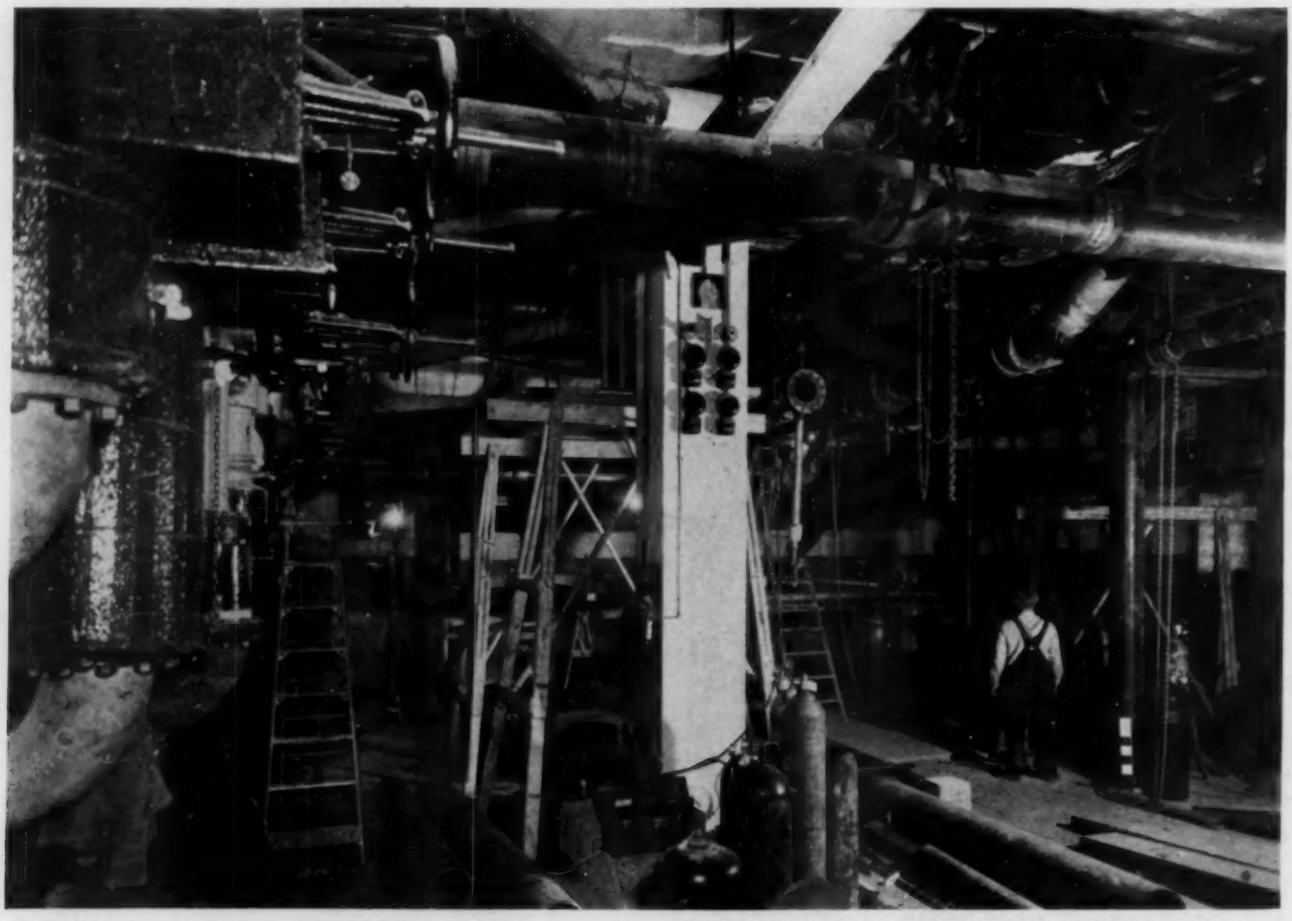
Approaching wheelbarrows laden with a mix is an indication to the sheet metal foreman that field sketches are to be prepared for shop fabrication of vertical duct work. Interest of the pipe fitter is directed to installing steam and water risers, and their subsequent connection to a source of supply. Take advantage of free, unobstructed working conditions to erect vertical runs of pipe and sheet metal first. Later, after arches are stripped of forms, start horizontal runs at the riser and proceed away from the chase. In this manner a crew of men may work on each floor.

Elevation of Work

Because of the method of supporting horizontal runs, both trades regulate the elevation of their work from the finished floor by a measurement from the underside of the arch above. This practice affords a fast, easy means of maintaining the runs within the space allotted between arch and hung ceiling. Where space is limited, verify measurements from bench marks. Sometimes, the undersides of the steel beams and reinforcement are covered by a heavier thickness of concrete fireproofing than originally planned. When the lather later obtains a measurement from finished floor to establish an exact height of plastered ceiling, if both measurements overlap, a smooth bottom of distributing duct may assume the appearance of a washboard.

Hoisting Equipment

At the approach of the appointed delivery date for large equipment,



Take advantage of free, unobstructed working conditions to erect vertical runs of pipe and sheet metal first. Later, after arches are stripped of forms, start horizontal runs at the riser and proceed away from the chase, says the author

such as fans, compressors, coolers, etc., study ways of entering the building in conjunction with existing means of hoisting equipment to the desired elevation. Make use of the bricklayer's and stone mason's hoists where possible. Perhaps an open elevator shaft will serve the purpose. If facilities are inadequate, arrange to secure the services of a licensed rigger for a day when everything to be hoisted is on hand. In the meantime, to insure a single handling, prepare foundations with consideration of means to isolate vibration.

Every rigging job is a precarious undertaking. Be sure the individual hired is competent and insured for property damage and public liability. A mistake in judgment or the use of faulty tackle invites catastrophe.

Prior to closure of the building exterior by the bricklayer, erection of pipes and ducts in tenant areas is complete. Control air piping for room thermostats has not been forgotten. Hydrostatic tests are accomplished where required, and the application of temperature insulation is favorably advanced. Collars on branch ducts for later attachment of grilles and registers extend the proper distance to align with subsequently plastered walls and ceilings.

In a few days, masons establish furring lines and erect rough interior walls and partitions. An iron framework covered with lather's wire to support a plastered ceiling hangs from the arch and conceals the handiwork of past months except for intended openings. An examination of a rapidly growing interior reveals proper disposition of supply and return outlets for the passage of conditioned air.

Apparatus Rooms

While other trades are engaged in the finishing of tenant interiors, strive to complete apparatus rooms. Fans previously set are leveled and balanced. Louvers, screens and filters are properly arranged in the outside air intake. Erection of cooling coils supported in a prefabricated frame from the dehumidifier pan enables assembly of the sheet metal casing. Preheaters are installed within the casing, allowing for correct pitch of steam and return lines. Chilled water pipes with provision for adequate drains and vents are carried from the cooling coils, simultaneously with the continuation of condenser piping, for subsequent connections to the refrigeration machine.

Where the supply riser of each zone pierces the arch of the apparatus room, a fire damper is inserted and the run continued through individual reheaters to a common terminus at the discharge of the supply fan. Return air risers are appropriately connected through the return fan to the dehumidifier and relief. Dampers responsive to control instruments, and air compressors furnishing control air, are placed and given preliminary adjustment. Sprays providing for winter humidification are piped to a source of city water, and if the electrician maintains the pace, controllers are set and wired and motors tested for proper rotation.

The remaining work involves alignment of fan and motor sheaves, and the application of belts and guards. The system for heating, humidifying and circulating air to tenant areas under automatic control is ready for temporary operation.

While sheet metal workers fasten air diffusers, registers and grilles to outlets, fitters are connecting condenser and chilled water pipes to pumps and refrigeration machine. Installation of a balancing tank to assure a full head on a closed, chilled water flow cycle between pump, dehumidifier and refrigeration machine completes construction activity of the fitter, except for the application of hydrostatic tests to detect porous fittings or faulty connections.

A specialist in the installation of refrigerating equipment inspects the machine for defects and omissions. If the code requires a pressure relief for refrigerant gas, a line from the relief valve to the atmosphere cannot be forgotten. The refrigerant sides of cooler and condenser are filled with a non-combustible gas to obtain a slight pressure, and all parts minutely examined for leaks. Satisfied that all is in order, the gas is exhausted and a vacuum applied for the dual purpose of dehydrating the machine and procuring another check on the degree of tightness of the system. When differential pressures relative to a corrected barometer remain substantially constant over a period of time, the machine is charged with refrigerant.

After various mechanical and electrical protective devices are tested, if load conditions permit, water systems are filled and vented, pumps are operated and the compressor brought up to speed. The result of considerable effort is realized in the production of adequate, economical and vibrationless refrigeration.

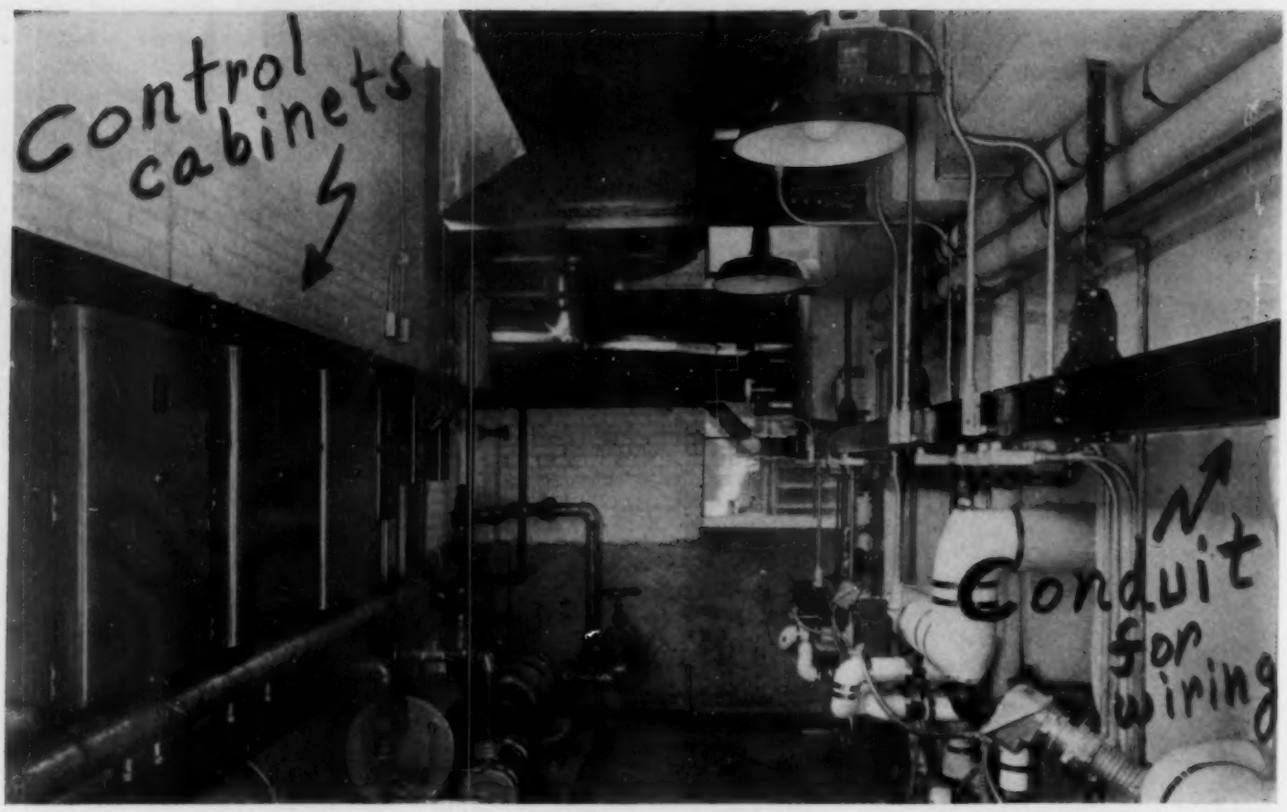
[*Mr. Sperzel's next article will cover balancing the air distribution, control adjustments, operating and maintenance instructions, etc.*]

ODORATED TALKING PICTURES

In the search for more realism in motion pictures, various additions have been made, such as sound, color, third dimension, and now, odor. Odorated or osmic talking pictures are the invention of two Swiss engineers. The New York Fair saw the first demonstration in the U. S.

The film shown was a talking picture of 35 min duration, accompanied by "passages" of odor each lasting a few seconds and covering a wide range of subjects.

The odors were directed into the faces of the osmience (if that is what the participants should be called). The osmic or scent film is elementary at this stage, but its odor quality is fundamentally good. According to the inventors, large theaters may be more suitable than small auditoriums for odorated pictures.—Industrial Bulletin of Arthur D. Little.



At the left is shown the method of enclosing all controls for each boiler in a fireproof, compact cabinet box delivered to the job all wired and ready for final connections. An interesting feature of this installation, also shown in the picture, is the use of the new square duct for the electrical wiring between the control panels and the oil burners

The Use of Heavy Oil *in* Today's Boiler Plant

Paul R. Unger, Mid-West Heat Service Co., Describes Modern Equipment for Factory and Building Heating

SUMMARY—Here is a discussion of modern methods of burning the heavier fuel oils in the boiler plant of today, written by a man actively engaged in this field and who is responsible for installations in many prominent industrial plants and large buildings. While not a description of any one job in particular, it is representative of numerous installations, including some at such defense establishments as aircraft plants, arsenals and factories. Engineers and contractors concerned with construction or modernization of defense industry plants where oil is to be the fuel will not want to miss this informative picture

A FEW years ago, if someone had asked for an automatic oil burning system for a 200 hp boiler which would still be full floating whenever possible, so that starting and stopping occurred only when beyond the range of the combustion control system, and which at the same time would be completely protected from the point of view of safety, we would have said it was a large order. Today, orders of this kind are taken as a matter of course and the trend is in the direction of new refinements designed to achieve the objectives of greater economy, increased efficiency, space saving, safety and dependability—all with less attention and supervision than ever before on the part of the operator.

Keeping the Oil Warm

It was discovered early in the process of trying to burn the heavy, cheaper oils that it was essential to keep the oil in the storage tank warm. This was first done by running horizontal pipe coils along the bottom of the oil tank from end to end. Later it appeared that it was necessary to heat only that portion of the oil adjacent to the oil suction stub. If steam is available, this can

be done by putting a vertical spiral steam coil through a separate manhole down near the bottom of the tank concentric with and surrounding the suction stub. If the oil return line is also run to the bottom of the tank, the oil returned from the circulating system will help to keep the tank warm and reduce the steam requirement. Where there is not enough steam pressure to return the condensate from this type of coil, hot water can be circulated through the coil in place of steam, using a transfer heater supplied with low pressure steam from the boiler plant.

In many cases today where a single tank is used, coils may be omitted and a hot well installed. The hot well consists merely of a piece of 4 or 6 in. pipe run down through the tank to a point 4 in. from the bottom with a 2 or 2½ in. suction stub down the center of the larger pipe and terminating about 2 in. higher than the larger pipe. Warm oil coming back from the circulating system is returned down the 6 in. pipe and immediately taken up warm by the 2 in. suction stub. This is an excellent method of maintaining tank temperatures. It cannot be utilized, however, with more than one oil tank in the same plant as it depends for its success upon the circulation of hot oil and under such conditions starting a second tank would be difficult, since it would be lying idle full of cold oil.

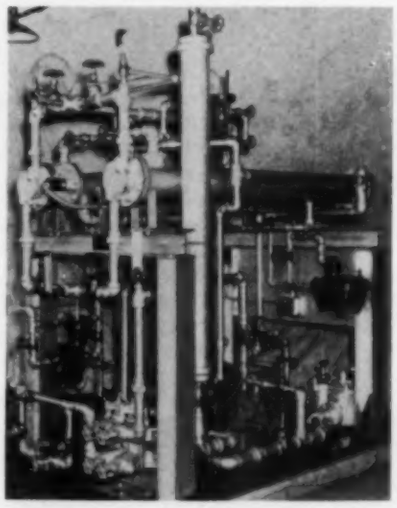
Another method of starting a heavy oil plant without any source of steam whatever, and of keeping the oil lines warm, is by electrically heating the entire oil line from the bottom of the suction stub to the tip of the burner. This is done by passing current at extremely low voltages through the piping itself. The wattage required ranges from 4000 to 10,000, depending upon the size of the plant. With this system a hot well should be provided or a much greater amount of current will be required.

One important point in the installation of a system of oil storage tanks and the accompanying oil, steam or water piping from the tanks to the boiler room is to make all of the piping as accessible as possible. A good method is to provide a covered trench for the oil and steam lines from the boiler room to the tank. Such a trench may be packed with wool felt or rock wool to minimize heat losses.

Heating and Piping Units

Oil storage tank temperatures are maintained just high enough to facilitate pumping the oil; any further increase in oil temperature is achieved at the oil pumping, heating and straining equipment in the boiler room.

There have been great strides in giving the plant a complete unit system to deliver the oil to the oil burners at the proper pressure and tem-



A compact oil pumping, heating, straining and metering set, all in duplicate, designed for 1000 boiler horsepower at 300 lb operating oil pressure. Total floor space required is 4 ft by 7 ft 6 in.

perature. Today's purchaser of such equipment is becoming accustomed to one complete pumping, heating and straining unit, all on one base, interconnected and ready for service. The unit generally consists of a duplex oil suction strainer (so that either side may be cleaned without turning the burners off); twin oil pumps, either of which is ample to take care of the complete boiler load; two steam or water actuated oil preheaters; two electric heaters for starting purposes—all with thermostatic control; and duplex discharge oil strainers, necessary thermometers, pressure gages, strainers, valves and oil meters. These units may even be delivered all wired with motor starters and disconnect switches mounted right on the unit.

In plants where high pressure steam is available, these pump sets are usually built with one electric driven and one steam driven pump so that in case of power failure, the heating plant can still function (unless, of course, the burners require motor driven equipment). Duplicate equipment is furnished in this type of unit so that in case of failure of any one part, the unit as a whole can continue to operate. It is possible to move the unit in the event of changes in the plant layout without disconnecting or reconnecting very much piping.

Oil Burner Control

In the application of the oil burner itself to the boiler the development has been along the lines of increasing over-all safety and operating efficiency and lessening of maintenance. In the past, many small boiler plants were made completely automatic; that is, the burners started and stopped with a pilot to ignite the oil. The larger plants were either operated by hand or were equipped with some sort of device to make the fire larger or smaller. Today most low pressure boiler plants, regardless of size, are being made completely automatic.

This, of course, brings up a number of control problems. Starting a burner rated at 100 gph is a far different problem from starting a burner rated at 15 gph. Early installations of large automatic burners brought with them "puffs" from throwing a large fire on at one time and inefficiency because the fires were starting and stopping every few minutes between certain pressure limits.

Puffs have been eliminated by arranging the system so that the burner starts with a smaller fire and gradually increases its size in proper ratio with the incoming air. Inefficiency from frequent starting and stopping has been done away with by the provision of some intermediate combustion control system between the cut in and cut out points of the automatic control system to operate the burner with a continuous fire and maintain constant pressure at the same time. In other words, while the burner is really entirely automatic (in that it will start and stop), the automatic controls are not governing except at such times as the smallest fire makes too much steam. At all other times, the burner responds to changes in steam demand and auto-

matically graduates the size of the fire.

Draft Control

Another defect in early automatic installations was that during the period the burners were off, the air would still rush through the boiler and out the stack and thereby increase fuel consumption. Modern overfire draft controllers are now available which will maintain a constant draft in the furnace when the burner is running, close the damper doors each time the burner stops, keep the damper closed while the burner is not running, open the damper wide before the burner can start again, and continue to maintain the correct draft after the burner is lit. This type of equipment will pay off the extra investment required in any low pressure boiler plant larger than 75 hp where freedom from particular attention is desired, in my experience. It also eliminates refractory maintenance caused by the burners starting and stopping frequently, alternately chilling and heating the firebox. In addition, it cuts down burner maintenance because the motors are not constantly starting and stopping.

The obvious questions one would ask when considering equipment of this type for a large boiler are: Is it safe to have dampers opening and closing in connection with an oil burning system without an attendant in the boiler room? Is it desirable to have these large burners starting by themselves? The answer is, "Yes, if adequate controls are provided." Here are six safeguards which may be termed "musts":

1) It is essential that the oil be at the proper temperature before the burner can start. This may be accomplished by the use of a double circuit thermostat in the electric heater adjacent to each burner, arranged so that the burner cannot start until the oil is at the correct temperature. This temperature will vary from that equivalent to 150 seconds Saybolt Universal to 250 seconds Saybolt Universal, depending upon the type of burner used.

2) The uptake damper should be wide open before the burner is permitted to start. This means that when the overfire draft control system is used to open and shut the dampers (as described above), the damper itself should be mechanically as well as electrically interlocked so that it is impossible for the burner to start should the damper fail to open.

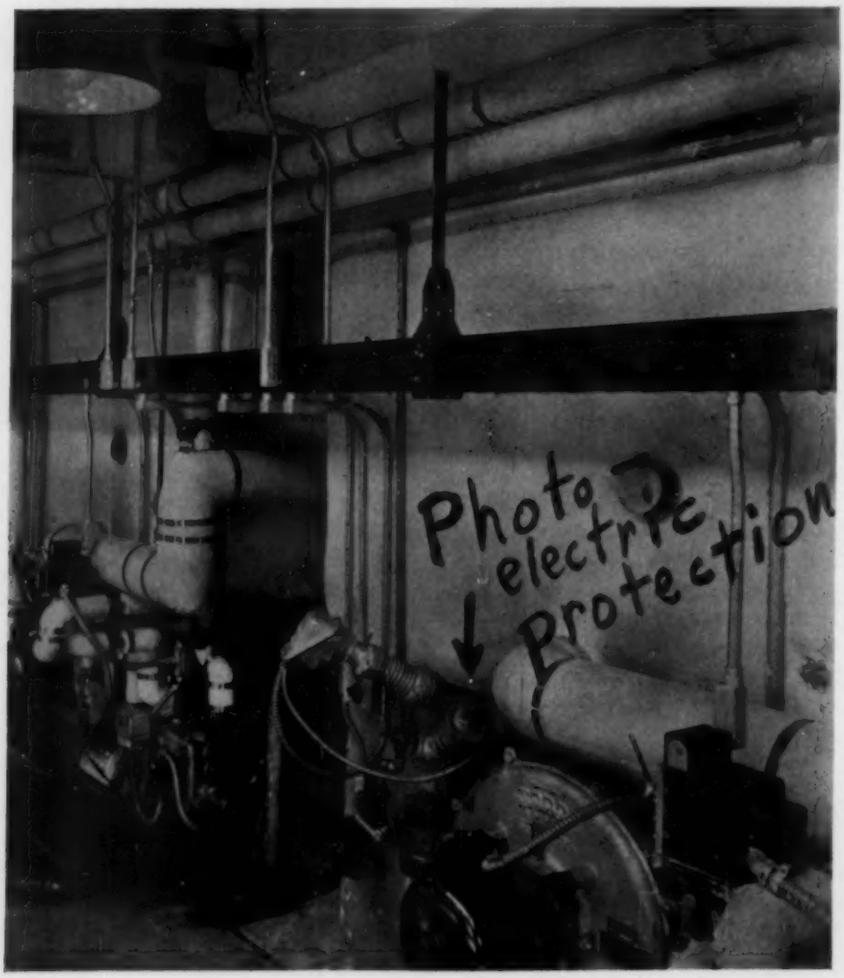
3) The gas pilot for ignition should be burning before the burner is permitted to start. Usually this gas pilot is ignited by an electric spark and in most control circuits the electric spark goes on simultaneously with the opening of a solenoid gas valve, lighting the pilot. The use of the safety control at this point is fairly recent. In the past, and even today in many installations, the oil burner control circuit assumes that the pilot is burning and permits the burner to start. The safety control in the stack turns the burner off in a period varying from 30 sec to 1½ min if the oil flame is not established definitely. This arrangement, while generally satisfactory in a smaller boiler plant, can be hazardous in a large one. It is possible, without the presence of the gas pilot, for the burner to deliver sufficient atomized oil to the firebox to cause an explosion if the brick work in the combustion chamber is not hot enough to light it instantly, but is just hot enough to cause it to light after a certain amount of oil is atomized during the timing period. A definite safeguard against this contingency is the use of a high temperature rod in the path of the gas pilot. When the spark lights the gas, the gas flame contacts this rod and completes an electrical circuit through a relay which permits the oil burner to start. Should the gas pilot fail to light, the oil burner cannot start.

4) The motor or other mechanism which starts the burner off with a smaller fire must be in the proper position so that the smaller fire will result when the burner starts. This again is a question of mechanical and electrical interlocking of the low fire start system, as it is commonly called, so that the burner cannot start should this motor or mechanism be stuck in the wrong position.

5) The air for combustion must be at the correct pressure. This is usually accomplished by a vapor switch on the burner, interlocked so that the burner cannot start until this pressure has been established.

6) There must be sufficient water in the boiler for safe operation. A low water cut-off will prevent the burner from starting unless the amount of water is sufficient for safety.

When all of the above conditions



This industrial plant installation is a completely automatic system for burning Bunker C oil, with photo-electric protection of oil fires and pilot protection

have been met, there is little danger in automatic starting. There remains, of course, the possibility that one or another of the above controls may fail, which would necessarily result in the burner not starting and thus make loss of steam pressure possible. So that instant notice will be given that attention is required, the safety control system in a plant of this type is generally wired into a siren, into the auto-call system of the plant, or into the ADT system if the plant has no watchman at night. An example is the garage of the Chicago Tribune, where the safety control system is wired to the engineer's office in the Tribune Tower, two blocks distant, so that notice is instantly received if the burner cuts off, even though the entire boiler plant is operated locked and no member of the garage personnel operates the equipment.

Flame Failure

Once the burner is lit off and combustion has been established, we must consider the safety controls necessary to protect the burner in the event of flame failure during the operating period. As the gas pilot in a completely automatic installation is not maintained during the operating period but only during the starting period, there is need for a type of safety control which is instantaneous, such as a photo-electric cell looking directly at the fire.

Usually this photo-electric cell is designed to operate with the same relay which operates the pilot safety control. As soon as the fire is established, the pilot goes out and the photo-electric cell is brought into the circuit and thereafter guards the fire. Should the fire be extinguished for any reason, this photo-electric cell will immediately turn off the oil burner and the oil flow. After a purging period of a minute, it will again light the pilot and endeavor to start the burner. If a second failure occurs, the oil burner will stop completely and the alarm system will immediately give notice.

HPAC's Annual Air Conditioning Review, comprising statistics on number and horsepower of residential, commercial and industrial installations for 1939, 1940 and the totals to date, is scheduled to appear in February. Don't miss it!

Why Should I Air Condition?

Let's Look at the Record!

THERE are hundreds of good reasons for air conditioning industrial plants and commercial establishments. Here are a few specific examples which have been taken from information released recently by Edward T. Murphy, vice-president in charge of marketing, Carrier Corp. By their variety, they indicate the almost universal scope of the industrial and commercial advantages of modern air conditioning.

Razor Blades

Corrosion at the Gillette Safety Razor Co., Boston, has been practically eliminated as a result of installation of air conditioning equip-

ment for dehumidifying compressed air. The greater quantity of this compressed air is fed to the blade edging, sharpening, wrapping and packaging departments. A 100 *ton centrifugal machine was installed for supplying the refrigeration needed to dehumidify the compressed air. Despite the fact that the relative humidity in Boston is often in excess of* 80 *per cent, especially during the summer months, the dehumidifying equipment maintains a constant "Sahara desert atmosphere" at the plant today. Twelve departments rely upon this unit to furnish dry air.*

Nylon Hose

A worthwhile reduction in the number of "imperfects" in their nylon hose and a considerable speed up in production has been effected at the Archer Hosiery Mills in Columbus, Ga., since the installation of air conditioning at the plant. The reduction achieved in the cost of the second grade hosiery effected through air conditioning should amortize the cost of the equipment within a few years. While the air conditioning system is delivering the desired temperature and humidity for the product, it also provides ideal working conditions. Damage to stockings from the hand perspiration of the employees is also eliminated. Air filtering provides cleanliness that is resultful alike to workers and product. Experience is proving that even minor changes in temperature and humidity are problems which must be overcome in the manufacture of nylon and silk hose, as nylon, a synthetic material made from coal, air and water, is highly susceptible to variations in these conditions, as is silk. Tests made showed that variations of as much as 2 in. can occur in nylon hosiery when conditions of temperature and humidity are not constant. In the gray process room at the Archer mills where the seams of the stocking leg are sewed together and the foot attached to the leg, a temperature of 85 F and a relative humidity

of 45 per cent are maintained. This was the first room to be air conditioned. Identical conditions are maintained in the finishing room, where the hosiery is received for

inspection and packing. Cellophane wrapping for enveloping the hose was one of the factors requiring accurate weather control. Additional equipment, capable of maintaining any conditions within a temperature range of 80 to 85 F and a humidity range of from 45 to 55 per cent was installed to air condition the boarding room and knitting room completely and heat and ventilate the dye house.

Dry Goods

Out-of-town buyers spend more time in the Ely and Walker Dry Goods Co. store than in competitive wholesale dry goods houses in St. Louis, Mo., since installation of air conditioning. Last spring, it was decided to air condition the first four floors of the block long, seven story building at 1520 Washington Ave. Buyers had been in the habit of making the rounds of all the dry goods houses during their stay in St. Louis, usually dividing their time equally among them. When the air conditioning system was installed, it was found that the buyers spent more and more time in the Ely and Walker store, particularly on very hot days. Cleaner conditions at the store make it possible to display more merchandise with a very low percentage of spoilage resulting, it is said. In addition, cleaning and decorating costs have been reduced.

Bowling

Bowling is taking its place as a major summer sport as a result of the air conditioning of leading bowling alleys and recreation centers throughout the country. A 50 per

cent increase in total summer business and a 50 per cent increase in the number of women customers in summer were noted at the Phoenix Bowling Center, Birmingham, Ala., following installation of a 50 ton air conditioning system. In addition, it was found that the average bowler played 25 per cent more games since air conditioning was installed. According to owners of the bowling center, cleaning and redecorating costs were drastically reduced and employee's services were increased at least 10 per cent in effectiveness.

Buses

Passenger business on streamliner buses of the Bowen Trailways fleet, linking Texas with California and the East, has shown a substantial increase since installation of air conditioning. In the Southwest, where temperatures in mid-summer mount well past the 100 deg mark, travel comfort is the keynote.

Printing

Absolute humidity control—eliminating costly off-register printing on three and four color decals—has been effected through air conditioning the Superior Decalcomania Co. plant, Dallas, Texas. The air conditioning system, installed in 1938, maintains a year 'round temperature of 78 F and humidity of 54 per cent in the press and processing rooms at the plant. It was found that these conditions are most economical, resulting in substantial reductions in time as well as production costs. Decalcomania paper is very sensitive to changes in humidity of the air. Sudden increases in humidity in the processing room cause this paper upon which decals are imposed to curl or stretch to such a degree that the fine detail work required in various color designs fails to register properly. The presses are controlled by air and when the sheet is too long, or too short, the press will not carry it through the cylinders properly. Each color is applied in separate runs. Unless accurate humidity is maintained continuously for these runs, one color will not register with succeeding colors.

Rugs

Unchanging conditions of temperature, humidity and air pressure for laboratory tests of raw materials at the A. & M. Karagheusian, Inc., rug manufacturing plant in Freehold, N. J., have resulted in a more uniform quality rug.

Exacting tests to insure uniformity of raw materials are necessary in manufacturing quality rugs. Varying atmospheric conditions will affect not only the weight but certain characteristics of various components.

One of the principal tests, according to Samuel Hanson, manager of the rug manufacturing division, is the dissection of the rug into different components. Each component is carefully weighed in order to control both cost and quality of the product. Wherever weighing of a textile is concerned, a uniform testing condition must be maintained.

The test laboratory air conditioning unit was designed specifically to suit exacting needs of chemical science so that materials might be successfully tested under unchanging atmospheric conditions. In addition to providing temperature, humidity and pressure control, the unit cleans and purifies the air supply, filtering out dirt and dust.

Pig Iron

As a result of increased output and lowered production costs arising from the installation of air conditioning in two blast furnaces, Woodward Iron Co., Woodward, Ala., has placed a contract for air conditioning its third furnace. In awarding the contract, H. A. Berg, Woodward president, stated that air conditioning has increased pig iron output of the two furnaces by 10 per cent. At the same time, the coke requirements of the furnaces have been reduced by approximately 200 lb per ton of pig iron. Increased output was made necessary by requirements for iron and steel in connection with the national preparedness program.

Woodward is said to be the first blast furnace company in the world to install modern air conditioning. As in the case of the two present installations, a centrifugal refrigeration machine of 500 tons capacity will serve the third furnace.

Mr. Berg pointed out that the extension of the air conditioning systems saved "precious time" in increasing furnace output when it is vital for national defense. Otherwise, it would be necessary to build additional furnace capacity.

Photo copyright by Harris & Ewing

The Supreme Court building in Washington, D. C., is the only one the Supreme Court of the United States ever had to call its own. Until 1935, the nation's highest tribunal met in buildings occupied by other branches of the government in New York, Philadelphia and Washington. When the federal government moved to Washington in 1801, elaborate plans and provisions were made for housing the executive and legislative branches, but apparently no one remembered the judicial. Its new home, facing the Capitol across a wide plaza, is of white marble. The general dimensions of the foundation are 385 ft east and west and 304 ft north and south. At its greatest height the building rises four stories above the terrace or ground floor. The court room, around which the rest of the building centers, is 82 ft by 91 ft from wall to wall, 44 ft high, and requires 17,000 cfm

Meeting Different Air Conditioning Requirements With a Central System

Supreme Court Building Is Example of Zoning to Meet Varying Needs of the Occupancy . . . By S. P. Eagleton*

THE air conditioning system serving the Supreme Court building in Washington, D. C., comprises essentially six dehumidifiers in connection with which there are 16 supply fans. Two centrifugal refrigeration machines of approximately 375 tons total capacity cool the spray water for the dehumidifiers.

The building is divided into 13 sections, each of which is taken care of by separate conditioning apparatus under individual automatic temperature control. Several of these sections are supplied with dehumidified air from a common dehumidifier. In these cases two or more fans obtain dehumidified (or, in winter, humidified) air from a single dehumidifier or spray chamber. This arrangement allows all of the spray chambers to be situated in the basement and eliminates the possibility of water damage if the dehumidifier tanks overflow. It also simplifies the chilled water piping and pumping.

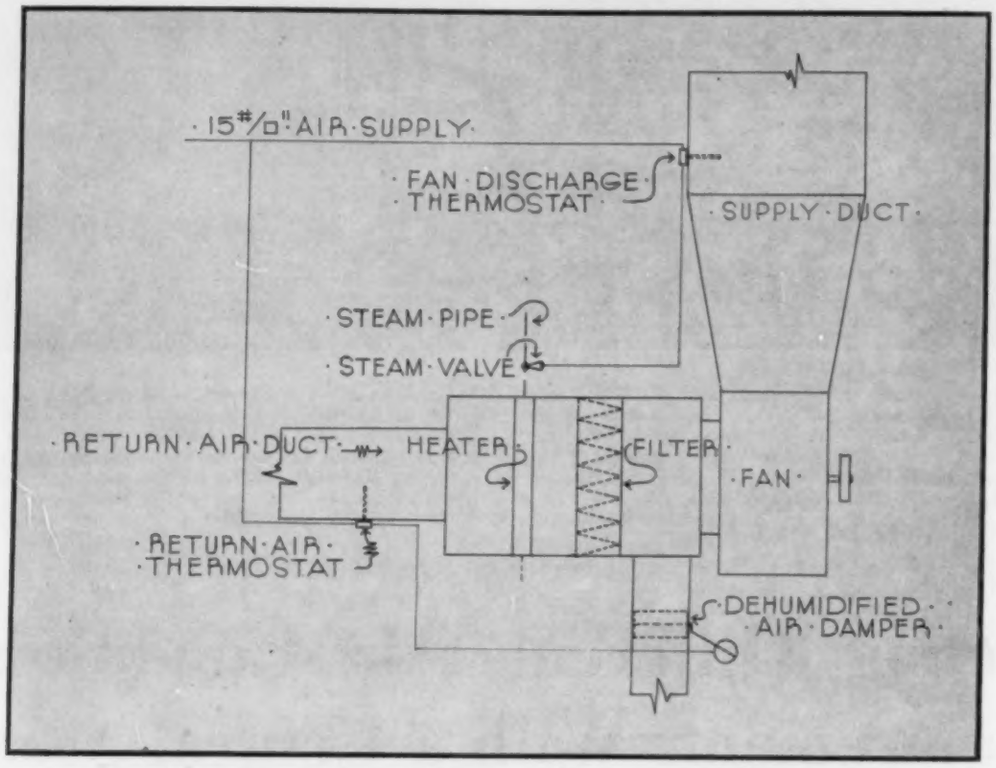
Outside air is taken in at the roof level through

SUMMARY

How to zone and control a central air conditioning system to meet the requirements of the various sections of a building is always a problem that must be given consideration by the designing engineer. At the Supreme Court building in Washington—which includes library and reading rooms, conference rooms, offices and office suites, dining rooms, and the court room itself—six dehumidifiers in connection with which there are 16 supply fans are used. Some of the dehumidifiers have partitions splitting them into separate sections and some of the fans operate in tandem, one fan supplying all dehumidified air to its companion (or companions) which handles a mixture of dehumidified and recirculated air. Two refrigeration machines totaling 375 tons furnish chilled spray water to the dehumidifiers. . . . One interesting feature of this installation—which is described in complete yet readable manner by Mr. Eagleton—is the use of exhaust air from the basement garages for cooling the condensing water for the refrigeration machines.

*Formerly Inspector of Construction in the office of the Architect of the Capitol, and to be Chief Engineer and Building Superintendent of the National Gallery of Art when it is taken over by the United States Government.

louvers and is brought to the basement through cork insulated masonry shafts to large plenum chambers at the sides of which are the outside air filters and the first row of preheaters. From the preheaters, insulated galvanized iron ducts on the basement floor conduct the air to the six dehumidifiers and two air washers. The second row of the preheaters is adjacent to and just in front of each of the dehumidifiers and the air washers. No outside air filters are installed in front of each dehumidifier, as all this air is cleaned by the paper mat filters at the foot of the masonry air shafts. Air filters of the same type are installed for filtering the recirculated air.



Typical arrangement of air conditioning systems Nos. 2*A*, 6*A*, 6*B*, 6*C*, 9*A* and 9*B*

Under the basement floor in front of the two refrigeration machines is a concrete water collecting tank. From this tank, two concrete return cold water trenches run to the six dehumidifiers. The cold water, after it has been sprayed in the dehumidifiers, overflows into these two trenches and runs by gravity back to the collecting tank. Three centrifugal pumps, one of 400 gpm capacity and two of 725 gpm capacity each, draw the water from this tank and force it through the refrigeration machine coolers to the six air conditioning systems. All three pumps are operated under maximum load, while under lighter loads only one or two are run. The use of two large capacity pumps and a single smaller capacity pump allows for flexibility for operating under reduced loads.

Capacity of the dehumidifiers and pumps is:

System	Dehumidifiers Cfm	Pumps Gpm
A	14,050	300
B	6,200	125
C	4,100	83
D	10,138	274
E	17,540	450
F	7,687	203

The Six Systems

System *A* serves the reading room, which comprises practically the entire third floor, and the special library space which occupies the remainder of this floor. Dehumidifier *A* is of the split type with a metal partition dividing it into two parts, the one being approximately 5 ft 2 in. wide and cooling the air for the large reading room and the other 24 in. wide and cooling the air supplied to the library space. A 25,000 cfm fan supplies a mixture of dehumidified air and recirculated air to the reading room, the proportion varying with the cooling load.

An air operated thermostat in the return air duct from the reading room controls dampers in the bypass duct connection, dampers in front of the dehumidifier, and a steam valve on the reheaters (which are adjacent to the bypass dampers.) This thermostat controls the temperature in the reading room by varying the amount of dehumidified and bypass air to the reading room during the cooling season, and the amount of steam admitted to the heaters during the heating season.

Two fans in tandem supply air to the special library. The first fan is situated at the discharge end of dehumidifier *A* and obtains all its air through the small section or division of the dehumidifier. Due to the long distance from the dehumidifier to the special library, it was considered necessary to provide a booster fan—this is the reason for the two fans in tandem. The fan at the dehumidifier (fan No. 2) handles 2800 cfm of dehumidified air and supplies it under constant static pressure to fan No. 2*A*, which is situated near the library. Fan No. 2*A* circulates the 2800 cfm of dehumidified air under maximum cooling load conditions plus 3700 cfm of recirculated air, a total of 6500 cfm. At lighter cool-

ing loads, automatic dampers controlled by a thermostat in the return air duct reduce the amount of dehumidified air and allow an increase of recirculated air. Extended surface steam heaters in the suction of fan No. 2*A* furnish the necessary heat to the supply air during the heating season. An automatic steam valve on the steam line to these heaters is under the control of a thermostat in the supply air duct.

System *B* serves the court room itself. The supply fan circulates 17,000 cfm. Under maximum cooling load, 6200 cfm is dehumidified air and 10,800 cfm is recirculated air. The control of the temperature in the court room is similar to that for the reading room. A thermostat in the return air duct controls the amount of dehumidified air, recirculated air and the steam admitted to the reheaters.

The supply air is discharged to the court room at the ceiling level through 24 special outlets situated above the plaster rosettes in the ceiling. Each outlet has four nozzles 6 in. wide by 2 in. high, directed down at an angle of 30 deg. The cool air leaving the nozzle at a relatively high velocity induces room air at the ceiling level to mix with the supply air; this provides for adequate air movement at the breathing line without drafts. Also, the temperature of the air circulated among the occupants is temperate, and there is no feeling of movement of cold air. Air is returned to the apparatus for reconditioning through mushrooms under the visitors' seats, through large narrow grilles under the rostrum, and low wall grilles in the front and rear of the court room.

System *C* serves the two conference rooms adjacent to the court room on the first floor. This system is of the split type with one fan obtaining its dehumidified air from one side of the dehumidifier and supplying it to one conference room after it is mixed with return air from this room. The other fan supplies air to the second conference room, and obtains its dehumidified air from the other side of the dehumidifier.

The air upon leaving the supply fans is conducted through the supply ducts to five long rectangular openings (6 in. high by 72 in. long) on each side of the conference rooms. These openings are evenly spaced along the length of the rooms about 5 ft below the ceiling and are situated just above wooden cornices which hide them. Consequently no grilles are used on these openings. Air is returned to the apparatus through two grilles in each room, in the end walls near the floor of each room.

In this system the controlling thermostats are situated just in back of the return air grilles at the ends of the conference rooms. These thermostats control the dehumidified and return air dampers, as well as the automatic steam valves on the steam lines to the reheaters.

System *D* supplies the dehumidified air for the second floor west reading room and the offices in the center wing on the second and third floors, as well as for the public dining room on the ground floor. This system is also of the split type, the dehumidifier having a partition dividing it into two sections. Fan No. 6, which is connected to the larger division, obtains all the air it handles, and which is outside air, through the dehumidifier and supplies it under constant static pressure to three recirculating fans (Nos. 6*A*, 6*B* and 6*C*) which in turn supply a mixture of return air and dehumidified air (which they obtain from No. 6 fan) to the reading rooms and offices they serve. In connection with each of fans Nos. 6*A*, 6*B* and 6*C*, there are installed air filters for the return air, and reheaters which heat the return air sufficiently to maintain the supply air at a temperature of from 68 F to 80 F, depending upon the outdoor temperature in the heating season. Each of the spaces to which these fans supply air have concealed radiation under the windows which is under thermostatic control. Experience has shown that the occupants are more comfortable in mild weather with air being supplied at about 68 F and during severe cold weather at about 80 F.

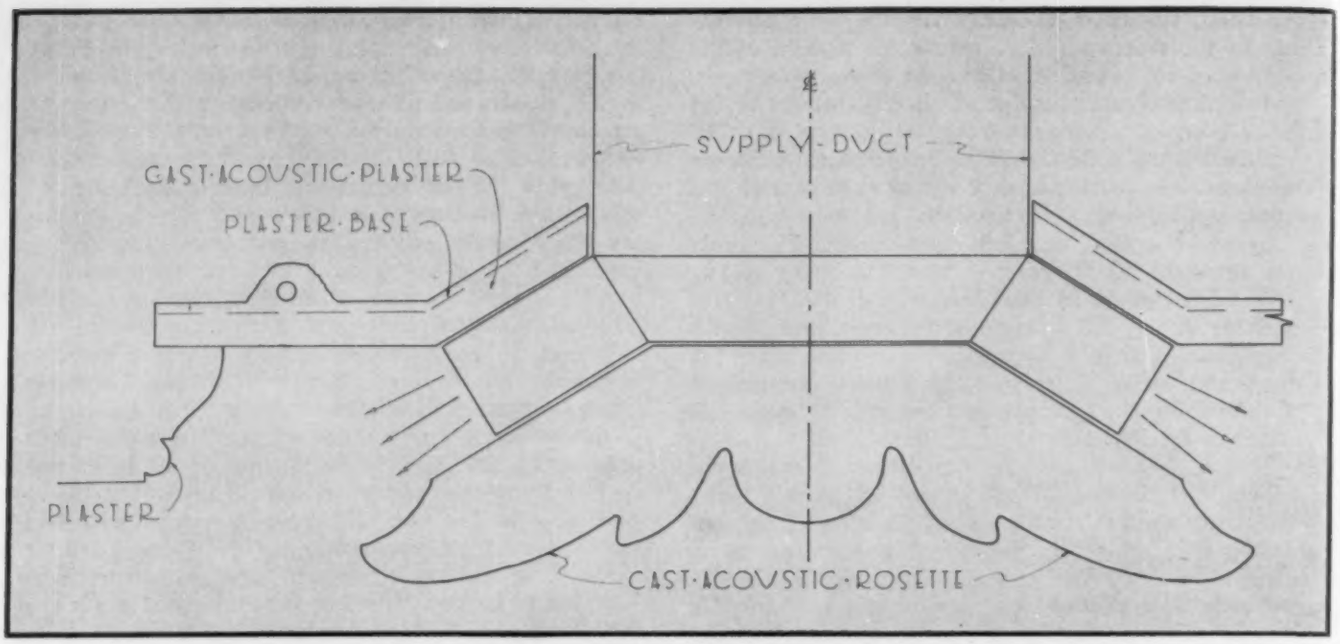
Two duct thermostats are installed in connection with each fan. The first is in the return duct and controls the damper in the dehumidified air duct from fan No. 6. If the temperature of the air returning from the rooms is too warm, the dehumidified air damper will be opened by this thermostat, allowing more dehumidified air at 48 F to enter the fan. If the rooms are too cool, this thermostat will close the damper in the dehumidified air supply duct and cause less cold air and more recirculated air to be supplied. The other thermostat (in the fan discharge of each fan) controls the automatic steam valve admitting steam to the heater in the return air duct.

Fan No. 7 draws outside air through the other division of system *D* dehumidifier, and supplies it to the public dining room on the ground floor. Return air is mixed with the dehumidified air under automatic control and the mixture is then supplied through six high velocity, rosette type grilles at the dining room ceiling.

System *E* supplies the dehumidified air to the justices' offices on the east half of the first floor of the building, and the justices' dining room, justices' library and librarian's offices on the east half of the second floor. This system is also of the split type, with fan No. 8 connected to one section of the dehumidifier and supplying all dehumidified air at 48 F to the window units under the windows in the justices' offices. The air is under static pressure control so that if any of the window units are closed by the occupants, excessive air will not be supplied to the other rooms on the system. Reheaters are installed in connection with this fan to heat the air supplied in winter to the window units.

Fan No. 9 supplies air to the justices' dining room and to fans Nos. 9*A* and 9*B*. The operation of these fans is identical with that described above in connection with fans Nos. 6*A*, 6*B* and 6*C*. The thermostatic control is likewise identical.

System *F* air conditions the office suites on the first floor on the west side of the building. This system—like the others— consists of second row preheaters, dehumidifier, reheaters, fan, recirculation pump and control. All of the air handled by this system is outside air, since it supplies the window units in the offices. The air is supplied to these window units under about ¼ in. static pressure. The air passes through a nozzle and at this pressure causes room air to be drawn in at the lower grille by induction. In summer, the air leaves this nozzle at about 48 F and after being mixed with the induced room air, enters the room through a grille in the window stool at about 66 to 70 F. The occupants can control the quantity of cool air admitted by operating a handle on the face of the window unit. In order to prevent the static pressure increasing at the fan dis-



Supply air for the court room is discharged through 24 special outlets installed above the plaster rosettes in the ceiling. This is a cross-section of one of the outlets. Each outlet has four nozzles directed down at an angle of 30 deg; the cool air leaving at high velocity induces room air at the ceiling level to mix with it in order to provide adequate air movement without drafts

charge when several of the window units are closed, a static pressure control is installed to maintain an even static pressure of about ¼ in. in the supply ducts.

There are two air washer systems, which handle 100 per cent outside air, supplying the main entrance hall and the stack rooms and the two large vaults on the ground floor. Each of these systems has a room thermostat controlling a multiple step type thermostat which in turn controls automatic steam valves on the reheaters. Each system also has a dew point thermostat which controls the quantity of steam admitted to the second row of preheaters during the heating season.

Exhaust Air Cools Condensing Water

The condensing water cooling system is also a part of the garage ventilating system. (There are four garages in the basement for the convenience of the justices and the employees of the court.) Two large spray chambers of 50,000 cfm capacity each are installed in the west end of the basement. A system of concrete underfloor ducts leads from each garage to the coolers, the exhausted air from two garages going to each cooler. The air exhausted from the garages passes through the spray chambers where the condensing water is sprayed and cooled. In connection with each chamber there are installed two fans each handling 25,000 cfm which draw the air from the garages and discharge it to the roof.

This air is discharged approximately 250 ft from the outside air intake so none of the humid air enters the outside air intake directly. One interesting thing happened when the system was first operated; some of this humid air was directed by the discharge louvers onto the outside of one or two windows of the reading room. The cool glass in the summertime condensed moisture from the humid air on the outside of the glass.

[The author wishes to acknowledge the assistance of David Lynn, architect of the Capitol, and H. D. Rouzer, assistant architect of the Capitol, in the preparation of this article.]

AIR CONDITIONED BLAST FURNACE

Air conditioning equipment capable of removing from seven to 40 tons of water per day from the air blown into one of the world's largest blast furnaces, in order to more closely control the quality of the iron produced, is to be installed on the No. 1 blast furnace at the Aliquippa Works of the Jones & Laughlin Steel Corp.

The equipment will be used to maintain a constant low moisture content in the air blast, eliminating the necessity of trying to outguess the weather 24 hr in advance of charging the furnace. Due to fluctuating moisture content of the atmosphere, operators must constantly change the proportions of raw materials, which approximate 2000 tons of iron ore, 950 tons of coke, 500 tons of limestone, and 4000 tons of air per day to produce 1000 tons of molten pig iron.

"Open for Discussion"

Communications to the Editor

Filtering and Dust Collection

THE EDITOR—

The article by Frank B. Rowley and Richard C. Jordan in the December HPAC indicates to me the necessity of careful differentiation between dust collecting problems and those involved in general air conditioning. In industrial applications where dusts in quantities visible to the naked eye are continually produced, air filters are not practical and some form of dust collecting apparatus is required. In such applications the number, size and chemical composition of the dust particles are of primary interest. On the other hand, in general ventilation and air conditioning work the volume of solid and semi-solid impurities is much less and we are usually interested in the volume of dust and its discoloration effects on outlet grilles and interior decorations. In studying dust problems and selecting the devices used to remove air impurities it is probable that more than one method of measuring efficiencies will be required.

In the foreword of the Standard Code for Testing and Rating Air Cleaning Devices adopted at the Detroit meeting of the American Society of Heating and Ventilating Engineers in June, 1933, there was the following note:

> It became apparent that a code suitable for laboratory testing of air cleaning devices used in general ventilation work would be entirely unsuited for rating cyclones, dust separators and the like or for the selection and rating of devices intended to supply air for dust hazardous occupations in accordance with the standards of the U. S. Public Health Service.

The scope of this test code was outlined as follows:

> SCOPE: This code is for the laboratory investigation and rating of devices used in general ventilation work for the sole purpose of removing solid impurities from the air. It is not intended for use in the rating of cyclones, dust separators or for devices used in the field of industrial hygiene. Ratings established under this code are not to be confused with operating efficiencies in actual service—the dust concentration, the nature of the dust, the relative humidity and many other factors have a definite bearing upon the results obtained in actual service.

I believe that the Rowley and Jordan discussions on this subject will be of interest to many of your readers. — H. C. MURPHY, Vice-president, American Air Filter Co., Inc. Member of HPAC's Board of Consulting and Contributing Editors.

Dust Concentration

THE EDITOR—

It is good to know that that very energetic man, Professor Rowley, continues to include the air cleaning problem among the many subjects in which he is so actively interested. [See article by Frank B. Rowley and Richard C. Jordan on predicting dust concentration, published in December.—ED.]

In my opinion the authors have presented a story well worth telling, although it is, like all previous papers on the subject, a contribution toward, and not a solution of, the air cleaning problem.

It might be said that the paper is somewhat heavy with theory, especially considering that the theory does not take account of air movements and of the agglomeration of dust particles in duct systems or after entrance into a room, which are undoubtedly very important. On the other hand, presentation of the theory is perhaps essential to as complete a statement of the case as is possible at the present time.

The paper implies a great interest in dust concentrations whereas I believe that so far as heating and air conditioning are concerned the main interest should be in how fast the dust can make things dirty. My suggestion is that Professor Rowley—or somebody—build or appropriate a room and inject some dusts, being sure to include very fine carbon (let us say, very, very fine carbon) among those used. In this way, settling rates or variation of concentration with time can be investigated and the soiling of walls, drapes and other objects can be observed, perhaps with the aid of photo-electric cells. A quantitive study of thermal precipitation in the room would be interesting also.—RICHARD S. DILL, Mechanical Engineer, National Bureau of Standards.

Readers of HEATING, PIPING AND AIR CONDITIONING are invited to contribute their views to these "Open for Discussion" pages, which will appear from time to time. Comments on articles we have published, expressions of timely interest on developments in design, installation, operation or maintenance of heating, piping or air conditioning systems, other remarks of value to HPAC's readers — all will be welcomed by THE EDITOR.

Compressor Horsepower Tables

THE EDITOR—

We have no comment to make on Mr. Goodman's article on horsepower requirements of refrigerating compressors other than that emphasis should be placed in the summary to the effect that the horsepower referred to is *theoretical*. No doubt this form of table which Mr. Goodman has prepared will be found extremely useful, simple and rapid when determining theoretical horsepower per cubic foot of piston displacement. No doubt the theoretical horsepower values can be more easily determined because of the physical measurements of the compressor which are known or can easily be determined. The fact, of course, must not be overlooked that tonnage of refrigeration effect also becomes a factor in many of the determinations.

Naturally, we will be very much interested in seeing others of this particular series of articles, with possibly greater mention given to volumetric efficiency tables or curves and over-all power efficiencies in the way of tables or curves.

It is my opinion that Mr. Goodman has done a very nice job and gone through a tremendous amount of tedious calculation in producing his table and if these articles are carefully read and the data properly applied many short cuts in calculations will be found.—R. J. THOMPSON, Refrigeration Engineer, Kinetic Chemicals, Inc.

How Big Is a Boiler?

THE EDITOR—

My first contact with the question, "How big is a boiler?", occurred about 18 years ago at my first meeting of the ASME. The discussion at this meeting brought forth the comment from one venerable member that it reminded him of a similar discussion 38 years before. It would seem to the uninitiated that a controversy as old as this one must be extremely complicated not to have been settled long since.

Rating by definition requires a standard. If the standard cannot be set then ratings should not be made and the purchaser of an article falling into this category must depend upon a manufacturer's warranty. If, on the other hand, it is possible to arrive at a standard there should be but one basis of rating. The standard will not necessarily provide in addition to a basis for rating a basis for selection of a boiler since boilers may be used for several purposes. Any basis of rating other than that determined by means of an established test procedure tends to stifle initiative in design of improved boilers on the one hand, and to encourage the production of poor equipment on the other. There are several procedures for conducting boiler tests. The more complete the data derived from such tests, the more information is available to designer and manufacturer. This is desirable because as he accumulates data his designs become more and more intelligent. The application of boiler test data insofar as heating boilers are concerned should be applied within the limits imposed by a heating system. Professor Seeley, of Yale University, has stated that the publication of data on heating boilers in addition to this is "useless to the consumer and may be dangerous."

Nozzle output of a heating boiler in itself is of no particular value unless the steam can be absorbed by the heating system. Therefore, the rating of a boiler should be published with due consideration to the limits imposed upon it by the system. In the practical use of heating boilers in buildings, it is necessary to consider questions of safety. Excessive stack temperatures are not conducive to safety and, therefore, a limitation of stack temperatures should be included in the test procedure. The combustion efficiency during the test should be maintained within limits which it is practicable to duplicate in the actual installation. The AGA and the IBR have recognized these conditions in their codes.

Given a uniform test procedure and a practical method of applying the data to ratings, questions of ratio of grate area to heating surface, heat release, ratio of prime to secondary heating surface and the question of how heating surface is to be measured become merely academic.

Messrs. Steiner and Ravnsbeck, in their article in the October, 1940, HPAC, presented the subject very clearly and with evidence that they are quite familiar with the questions involved. It is to be hoped that their article will be widely read and seriously considered by all manufacturers of boilers.—ROBERT K. THULMAN, Mechanical Engineer, Technical Div., Federal Housing Administration.

Drug Store Conditioned

THE EDITOR—

Bullard and Shedd Co. of Keene, the oldest drug store in New Hampshire, celebrated its 100th anniversary this past summer by installing air conditioning.

The "centennial" air conditioning equipment consists of a 3 hp unit air conditioner. Since space in the store proper was limited, the equipment is installed in a basement storage room, with supply and return air duct connections to the selling area upstairs. Conditioned air is distributed throughout the store from grilles in an inconspicuous duct running the length of the room. Because of low headroom in the basement, the unit was installed in two sections, one containing the refrigerating machine, and the other the air conditioning coils, fan and controls.

The air conditioning equipment was installed in two sections because of low headroom in the basement. The cabinet in the foreground contains the refrigerating machine and the rear section houses the air conditioning coils and the fan

Commenting on the air conditioning system after two months' operation, Paul Shedd, president and general manager of the store, declared that customers who come in completely wilted on a hot day, leave the store refreshed and grateful for the comfort he has given them. Also he has some specific comments for other druggists.

"There has been a marked decrease in dust on our shelf goods," he said, "and sweeping the floor is now almost unnecessary because both the dust and particles of dirt are continually removed by the filter in the air conditioner. Furthermore, candy keeps its original sparkle in the air conditioned environment because the cocoa butter content is not disturbed by daily temperature fluctuations. Cigars neither become dry and brittle, nor soggy and limp as they formerly did, even when we kept a wet brick in the display case. In fact, we are going to merchandise them from an open shelf display."

But the greatest advantage of air conditioning in the drug store, he feels, is the increased comfort and vitality of the sales force.—J. T. SCHAEFER, General Electric Co.

Air Conditioning Coils

THE EDITOR—

In his article in the October HPAC, F. F. Stevenson called attention to an important point in regard to the choice between a small or high temperature rise for water coils in air conditioning work. He brought out the possibilities regarding water velocities, mean temperature differences, coil size, surface temperature and relative amount of dehumidification. I do not think that most engineers appreciate these differences.—G. L. TUVE, Professor of Heat-Power Engineering, Case School of Applied Science.

Evaporative Cooling Map

A. J. Rummel* Indicates Sections of U. S. Where Climate Makes Direct Evaporative Cooling for Comfort Practical

SUMMARY—From studies of evaporative cooling for comfort, it appears that best results are achieved when the outside dry bulb temperature during the daytime is 90 F or more, and that most successful use is limited to the times when the outside wet bulb temperature is below 75 F. The dotted contour lines on the accompanying map therefore designate the number of hours that the outside dry bulb is above 90 F from 9:00 a. m. to 5:00 p. m. for June, July, August and September. The solid contour lines indicate the number of hours the dry bulb temperature is above 90 F plus the number of hours the outside wet bulb is below 75 F during the same period. Analysis of the map indicates there are a number of sections where the wet bulb temperature would make evaporative cooling practical, but where the dry bulb temperature would hardly justify its use

FROM a study of operation of evaporative cooling for comfort, it appears that most satisfactory results are obtained with these systems when the outside dry bulb temperature during the daytime is 90 F or more. Similar studies seem also to indicate that the most successful use of these systems is limited to those periods when the outside wet bulb temperature is below 75 F.

The accompanying map was prepared from meteorological records of the U. S. Weather Bureau. The dotted contour lines designate the number of hours that the outside dry bulb temperature is above 90 F from 9:00 a. m. to 5:00 p. m. during June, July, August and September. The maximum number of hours during this period is 976.

The solid contour lines represent the number of hours that the dry bulb temperature is above 90 F plus the number of hours that the outside wet bulb temperature is below 75 F during the same period.

Analysis of the map indicates that there are many sections of the country where the wet bulb makes the use of direct evaporative cooling for comfort practical, but where the dry bulb temperature hardly justifies it.

Although there is a large part of the country where considerable comfort can be derived from the movement of air only (without the evaporation of moisture), it is felt that the majority of people would not consider such installations justified unless they could obtain the maximum benefits during at least one-third of the summer season. Accordingly, the area shown on the accompanying map where evaporative cooling might be considered practical is limited to those sections of the country where the dry bulb temperature is above 90 F and the wet bulb temperature below 75 F for at least one-third of the summer season.

From this map a district or territory, such as Phoenix, Ariz., is shown to be approximately on the 1630 hr wet and dry bulb contour line and on the 800 hr dry bulb contour line. This indicates that, on the basis of the hours that the wet bulb temperature is below 75 F (1630—800 = 830), evaporative cooling might be considered effective 85 per cent of the total hours during the days of the four-month period, and on the basis of the number of hours that the dry bulb temperature is above 90 F, 82 per cent of the time. From this it is seen that evaporative cooling can be successfully used a large part of the summer in this territory.

In the vicinity of El Paso, Tex., the weather records indicate that the wet bulb temperature is below 75 F during the entire summer period, but that the dry bulb temperature is above 90 F only a little more than one-third of the time. Therefore, in this area the dry bulb would be the determining factor.

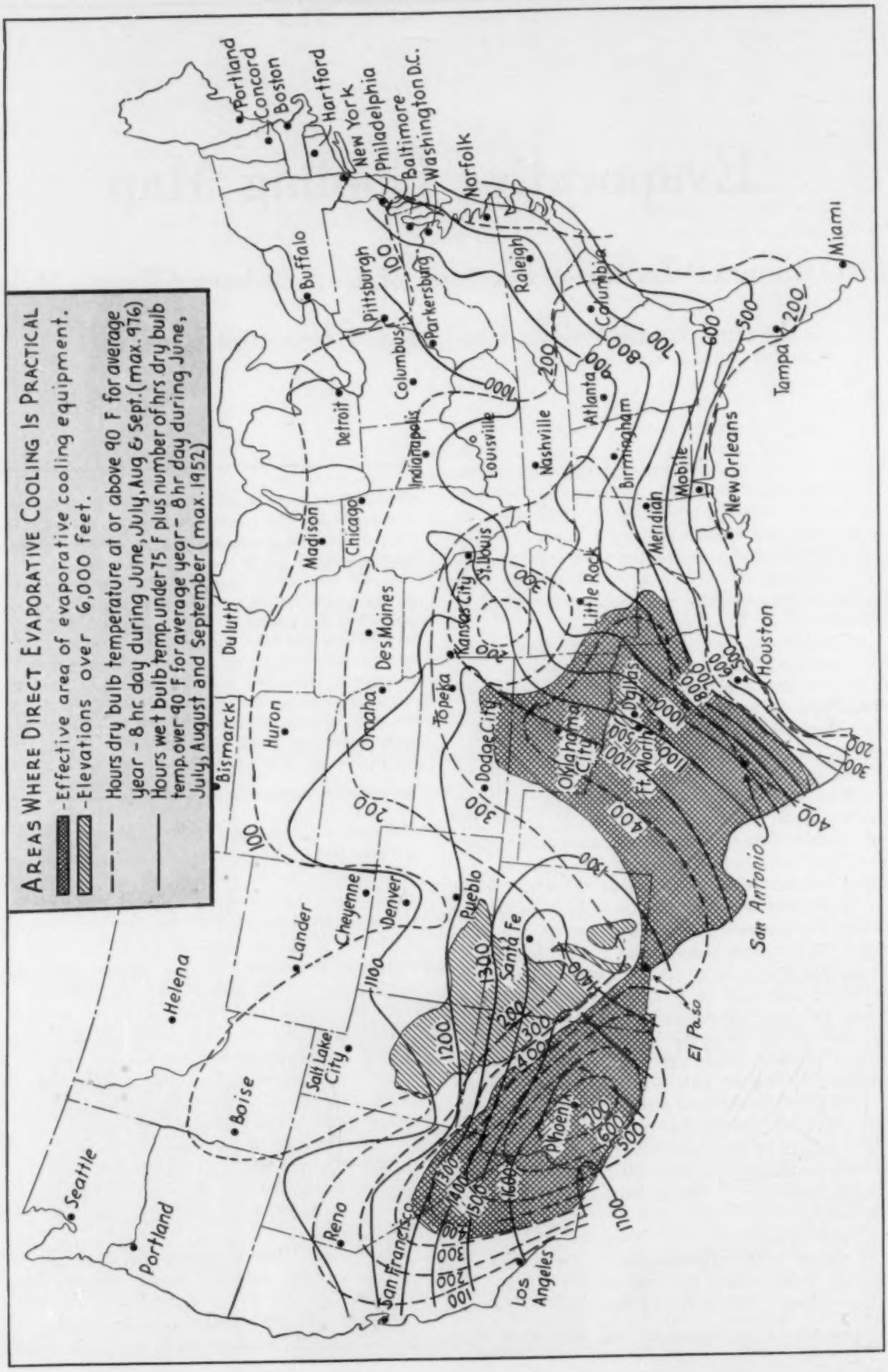
In the vicinity of San Antonio, Tex., it is noted that there are about 400 hr, or 41 per cent of the summer daytime hours, that the dry bulb is above 90 F and 600 hr, or 61 per cent of the time, that the wet bulb is below 75 F.

As the coast line is approached, as at Houston, Tex., where there are only 260 hr that the dry bulb temperature is above 90 F and about 330 hr that the wet bulb is below 75 F, the installation of direct evaporative cooling systems for comfort would not be justified.

*Air Conditioning Engineer, Commercial Dept., San Antonio Public Service Co.

Evaporative Cooling Map

[See text for explanation of map and its use]



Heating·Piping·Air Conditioning

AMERICAN SOCIETY of HEATING and VENTILATING ENGINEERS

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A Laboratory Method for Cyclic Heat Measurements on Walls and Roofs

By E. R. Queer* and F. G. Hechler**, State College, Pa.

SUMMARY—It has become increasingly important to determine the effect of heat capacities of walls and roofs, of sunshine, and of daily cyclic temperature changes for air conditioning and heating design. An adaptation of the guarded hot-box equipment is described for use with cyclic variable heat flows, which will give required data quickly and economically. Cyclic heat-flow tests are reported on a standard house wall construction. An assumed surface temperature cycle was imposed on the outside surface of the wall and tests were made with the wall uninsulated, insulated with a medium amount of very low density insulation, and with a large amount of low density insulation

THE guarded hot-box method for measuring the thermal resistance of wall or roof structures under steady state conditions, that is with constant temperatures on each side of the wall, has been well developed. If proper precautions are used this method gives satisfactory values not only for the over-all resistance of the structure but also yields results for the individual components of the wall agreeing closely with those obtained with the guarded hot plate. This paper describes the extension of the hot-box method of testing to the measurement of heat flow when one side of the wall is subjected to a varying temperature simulating outdoor conditions while the air on the other side is kept at a constant temperature. With the development of air conditioning this problem has become increasingly important because of the effect of heat capacity, of sunshine, and of normal daily cyclic temperature changes on the heat transmission of complete wall structures. The necessity for a suitable method for measuring cyclic heat flow has been frequently pointed out in the literature.[1, 2, 3, 4, 6, 8, 9]

This problem has been approached both analytically and experimentally. The analytical solution, based on an application of Fourier's series, is tedious and complex and beyond the ability of the average user. The experimental method depends on the use of a heat-flow meter, or its equivalent, to measure the flow through the wall or roof of the existing structure or of a special test house built for the purpose. The experimental method is laborious and expensive and is handicapped by the erratic and often unsuitable temperatures on one or both sides of the structure. The present method obviates many of these difficulties and makes it possible to carry out the required measurements under predetermined conditions economically and expeditiously.

*Assistant Professor of Engineering Research, Engineering Experiment Station, The Pennsylvania State College. MEMBER of ASHVE.

**Director, Engineering Experiment Station, The Pennsylvania State College.

For presentation at the 47th Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Kansas City, Mo., January, 1941.

The Test Equipment

The test equipment, which is a modification of the guarded hot box, is shown in Fig. 1. The wall to be tested is installed so that the outside of the wall, which is to be subjected to the variable temperature corresponding to outdoor conditions, faces an open chamber (*A*) provided with means for heating and cooling. On the other side of the test wall is fitted a removable guarded hot box, one side of which is closed by a standard panel (*B*), through which the heat flow remains constant during a given test. The thermal resistance of this panel is chosen so that the heat flow through it for fixed air temperatures in the cold room (*C*) and in the guarded box (*D*) will always be greater than the heat flow through the wall under test. During a test the heat passing through the wall changes with the temperature in chamber (*A*); consequently in order to keep a constant rate of heat flow through panel (*B*) the heat supplied to the guarded box by the heaters (*E*) must be changed correspondingly.

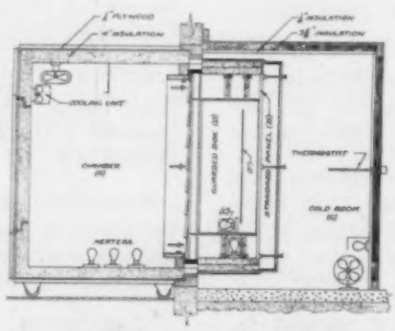

Fig. 1—Modified guarded hot-box assembly with test wall in position

The guarded box (*D*) has a light 1-in. wood frame covered on both sides with hard fiber board. The 1-in. space between the fiber boards is filled with a high grade mineral wool to provide some thermal insulation. The outer surfaces of the fiber boards are covered with 16-oz copper; the sheets on the two surfaces are electrically insulated from each other to facilitate the installation of thermocouples for obtaining thermal equilibrium between the inside and the outside of the box. The copper is painted black to minimize reflection of radiant heat. A black shield (*F*) 42 x 42 in. is placed 6 in. from the standard panel (*B*) to minimize radiation from the plaster surface to the standard panel which is at a lower temperature than the test wall.

The test wall consists of a common type of frame construction with a three coat, 5/8-in. thick plaster on 3/8-in. gypsum plaster base, 2 x 4 in. studs, 16-in. on centers, 25/32-in. wood sheathing, building paper, and 8-in. beveled siding. The con-

struction and method of holding the wall together are shown in Fig. 2. The wall is assembled with bolts and screws to make it easy to take apart to add or remove insulation. The method of assembly did not change the conductance from that normally expected for a wall of this type. The test area is 4 x 4 ft. in the center of the panel and the studs are arranged so that three full stud widths were covered by the guarded box (*D*). It should be noted that the air spaces within the wall covered by the test area are isolated from those covered by the guard ring.

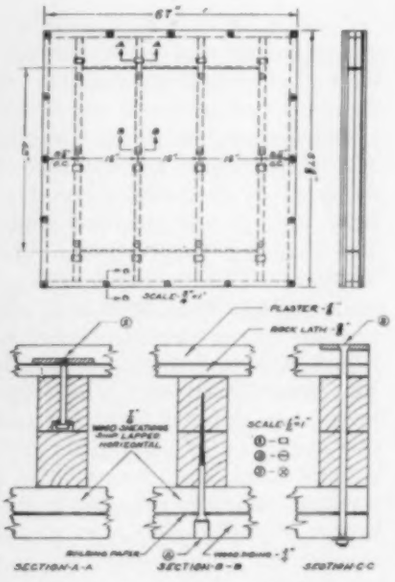

Fig. 2—Construction of test wall

The electrical circuits supplying heat to the component parts of the equipment along with the automatic control circuits are shown in Fig. 3. The temperature cycle on the outside of the wall was produced with exposed electric lights, fans, and a cooling unit. The heat flowing into or out of the wall on the outside was not measured. The heater units in the guarded box (*D*), and in the guard surrounding this box, consist of 120-w, 110-volt, clear, carbon filament electric bulbs. These are operated on low voltage and are carefully shielded to avoid direct radiation to the panel and meter. The heater units are located at the lowest level in the space being heated so as to make the temperature gradient between the bottom and top a minimum. The heat distribution was dependent on natural convection, as no fans were used on the plaster side of the panel. Shielded electric bulbs are also used to supply heat for maintaining the cold room at a constant temperature.

Because of the complex nature of the operation of the test equipment and the need for numerous readings as well as frequent adjustments to follow the prescribed temperature cycle, it was found desirable to make most of the control circuits automatic. The temperature balance between the inner and outer faces of the guarded box (*D*) is maintained with the balance circuit shown in Fig. 3. Single thermocouples with separate cold junctions are soldered to the center of each side of both the inside and outside copper sheets. The four thermocouples on the outside are paralleled, as are the inner thermocouples and these groups are connected in series through the galvanometer (*G*). The galvanometer reflects a light beam on and off a photo electric cell which operates a relay circuit to control the heaters for the guard surrounding the guarded box (*D*). When the guard side becomes warmer than the guarded box side the light beam is deflected onto the photocell and a portion of the heater units is turned off.

The necessity for an extremely sensitive thermostat for controlling the temperature in the guarded box became apparent early in the test. The sensitive bi-metallic thermostat used for steady state tests was not satisfactory because it had a tendency to block when the peak flow came through the wall. Five air thermocouples between the baffle shield (*F*) and standard panel (*B*) are used as the sensitive element of the thermostat circuit, shown in Fig. 3. These are connected in series with a potentiometer and a galvanometer. Deflection of the light beam by the galvanometer on and off the photocells operates the relays which turn a portion of the heaters on or off, as the case may be. A two-stage vacuum tube amplifier is used to operate the relays.† The power consumed in the guarded box was metered with a specially built portable watthour meter. In order to prevent the light beam from overshooting the photocell and losing control of the temperature, a mirror picks up the light beam as it leaves the first cell and reflects it onto a second cell in parallel with the first. Stops on the galvanometers will also serve to prevent overshooting. When the voltage is properly adjusted to the heaters, this thermostatic device will control the air temperature to ±0.15 F indefinitely. With a potentiometer storage battery having a low discharge rate the potentiometer needs to be standardized only twice in 24 hours. An additional advantage is that with the cold junctions in an ice bath and from a previous calibration of the thermocouples any desired temperature can be established in the guarded box (*D*) merely by setting the proper microvoltage on the potentiometer. Good operation of the device is dependent on low heat capacity heating units.

†The amplifier used is described in "Application of Conventional Vacuum Tubes in Unconventional Circuits", by F. H. Shepard, Jr. (Proceedings of the *Institute of Radio Engineers*, Vol. 24, No. 12, December 1936, p. 1574.)

Test Procedure

The temperature cycle to which the outside of the test wall is to be subjected is either assumed or else determined by measurement of surface temperatures of existing walls under the desired conditions. The temperature of the air on the inner side of the wall is similarly fixed by the assumed air temperature that is desired. Fig. 4 shows a temperature cycle curve starting at 70 F and rising to a maximum of 100 F; the room temperature in the meantime remaining constant at 75 F.

The test routine is usually divided

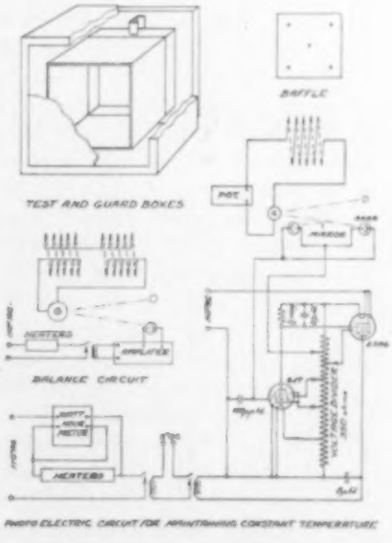

Fig. 3—Automatic control circuits

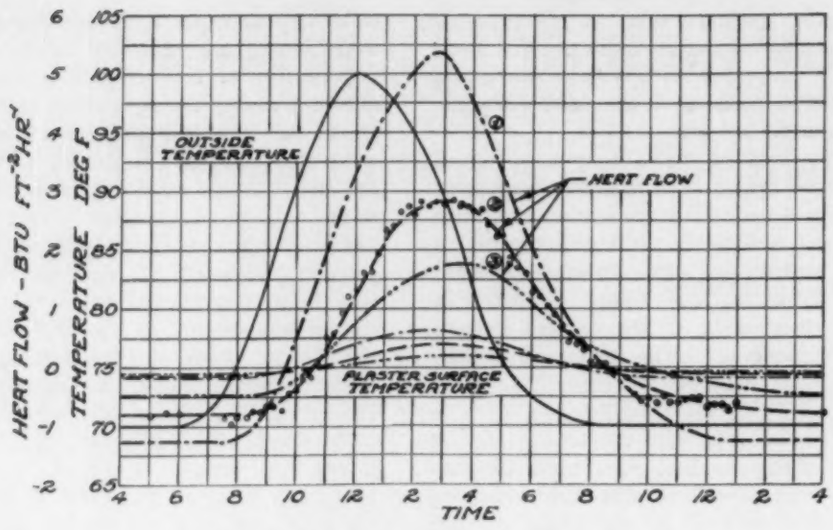
HEAT FLOW - BTU FT⁻²HR⁻¹
TEMPERATURE DEG F
TIME
OUTSIDE TEMPERATURE
HEAT FLOW
PLASTER SURFACE TEMPERATURE
6 5 4 3 2 1 0 -1 -2
105 100 95 90 85 80 75 70 65
4 6 8 10 12 2 4 6 8 10 12 2 4

Fig. 4—Heat cycle results on test wall

1. Uninsulated; $C = 0.29$
2. Insulated wall—1 sheet of reflective insulation on paper, next to plaster base; $C = 0.17$
3. Insulated wall—3½ in. mineral wool; $C = 0.10$

into four steps, (1) calibration of the standard panel to serve as a heat-flow meter, (2) measurement of conductance of the wall with a 25 to 30 deg temperature drop, (3) establishment of steady state heat flow through the wall for the initial temperatures with a conductance measurement for the small temperature difference prevailing under these conditions; this value should check the one obtained under (2); and finally (4) starting from the initial steady state condition the outside temperature of the wall is made to follow the prescribed temperature cycle for a 24-hour period while the air temperature on the inner side is kept constant.

The standard panel is calibrated by operating the cold room and the guarded box at the required temperatures, which must be maintained constant during the test, and making the outside wall surface temperature the same as the inside surface temperature. Under these conditions all of the heat supplied to the guarded box (D), when balanced with its guard, flows through the standard panel, or meter (B). Since the temperatures in (D) and (C) remain constant through the subsequent tests the heat flow through (B) also remains constant.

If the conductance of the test wall has not been determined previously it is customary to measure it, as indicated under step (2), by raising the outside surface temperature to give a 25 to 30 deg temperature drop across the wall. Heat now flows through the test wall into the guarded box and reduces the heat input required to keep the temperature in the box, and hence also the heat flow through the standard panel, constant. From the reduction in heat input and the temperature drop across the wall its conductance can be calculated.

The next step is to establish steady state heat flow for the initial conditions of the test, in this case 70 F for the outside of the wall and 75 F air temperature in the guarded box. The conductance of the wall is again calculated from these data as a check though, because of the small temperature difference, the results are not as dependable as those obtained with the larger temperature difference, step (2). As soon as equilibrium is established the test is continued (4) by imposing the required temperature cycle on the outside of the wall. The temperature cycle is produced by varying the voltage on the exposed lights in chamber (A) with an autotransformer. A cooling unit, which is operated continuously throughout the test, in the chamber (A) helps to produce the descending portion of the cycle by rapidly removing heat. The rate of heat removal is in excess of that required and the desired cycle temperature is maintained with the heater units. By this method a close and responsive control is maintained over the wall surface temperature. The cycle temperature is adjusted regularly every minute and all the temperatures as well as the power input to the guarded box (D) are read regularly in the same sequence at 15-min intervals. The principal purpose of the test is to determine accurately the heat-flow cycle through the plaster surface into the guarded box (D). The heat transmitted from the plaster into the guarded box is equal to the difference between the power input under steady state with both wall surfaces at the same temperature and the power input at the time desired, times a conversion factor.

Test Results

Prior to making each cycle run the apparatus was calibrated with the wall in place and the plaster and sheathing temperature at 75 F. Under the equilibrium condition no heat flows through the wall and all the input to the guarded box (D) flows through the standard blank. The sheathing temperature is then dropped to 70 F and held until the wall conductance is rechecked. An arbitrarily chosen temperature cycle, Fig. 4, was applied to the test wall. The conventional wall was tested under three different heat resistance conditions. First, the plain wall without insulation; second, with a medium amount of reflective insulation of negligible density in the air space; and third with a large amount of relatively low density blanket insulation in the air space.

A sample calculation for the heat flowing from the wall is given as follows:

For the heat flow at 4:00 p.m. for the reflective insulated wall.

4:30 p.m. power	728.18
3:30 p.m. power	646.75
	81.43

Steady state power 91.98 (heat flow through standard panel).

Heat flow = (91.98 — 81.43) × 0.2561 = 2.70 Btu per square foot per hour.

This value was plotted at 4:00 p.m.

The value from 3:45 to 4:45 is plotted at 4:15 p.m. The values plotted thus give the same curve as the 15-min power differences and they show less scattering. The heat-flow curves and plaster-surface temperature curves plotted in Fig. 4 show the magnitude and time displacement of these factors.

During the test the sheathing and plaster - base - surface temperatures

facing the studs were also read at 15-min intervals. These curves are omitted from the plot to avoid confusion. A proportionate number of thermocouples placed over and under the studs give due weight to the effect of heat flowing through these members on the various surface temperatures. A check of the results may be obtained by the plaster-surface coefficients while heat flows out of the plaster surface. When the average heat flowing into the guarded box (D) from the wall is divided by the average plaster-to-air temperature difference above 75 F the average still air-surface coefficient is obtained. The values for the walls tested are shown in Table 1.

Table 1

Wall	Conductance	Air Temperature, F	Average Plaster Temperature, F	f_i
No Insulation	0.288	74.7	75.7	1.48
Reflective	0.174	75.0	75.6	1.44
3¾ in. Blanket	0.101	74.8	75.1	1.49

These values are in reasonable agreement with the value 1.34, that is usually obtained in the guarded hot box under still air conditions. They also serve to confirm the validity of the results of a particular test.

The reliability of the conductance values measured by the modified guarded hot-box method is seen in the alignment of points, with respect to the mean temperatures, for the blanket insulated wall. Two tests were made on the wall at different mean temperatures by the conventional guarded hot-box method. The third test at the highest mean temperature was made by the modified guarded box method on the wall insulated in the same way as for the first two tests but with a different sample of insulation. The values are as follows:

Mean Temperature, F	Conductance
35.9	0.077
50.5	0.087
88.2	0.111

A plot of these values, conductance *vs.* mean temperature, shows excellent alignment of points and confirms conductance tests made with the apparatus assembly shown in Fig. 1.

The question may arise as to the accuracy of results where the heat flow depends upon the small differences between large numbers. In several cases cyclic tests have been repeated on test panels to determine the reproducibility of the results. In all cases the heat flow curves were the same. This may be construed as evidence that the automatic controls will function properly. It is felt that the heat flows measured by the modified guarded hot box are accurate because of the agreement between the conductance values obtained by the modified and regular guarded hot-box methods. The fact that the surface coefficients are also in close agreement with the steady state values is evidence that the method of measuring the heat flows in the modified guarded hot box is reasonably accurate.

Applications and Limitations of the Apparatus

In a wall or roof where heat flows under steady state conditions through all the component parts in series, it is a simple matter to calculate the resistance from our present knowledge of the coefficients of the individual parts. When there are parallel paths of heat flow in the structure it is still relatively simple to calculate the resistance of the wall under steady state conditions. Although the calculations are based exclusively on the steady state, such a condition seldom prevails for any extended period of time. The wall or roof is usually subjected to some sort of a temperature cycle which may make the steady state calculations deviate widely from the actual condition, particularly where the cycle is daily as in the case of air conditioning. As previously mentioned this condition adds to the complexity of the problem and makes calculations difficult. On account of the limited knowledge we have on heat diffusivity of materials in series and parallel combinations it is almost impossible to calculate heat flows in a wall under transient states. The test method for such conditions as described in this paper is relatively simple and should add much to our present knowledge of heat transmission.

If field observations are made on outside wall and roof temperatures, the cycles can be reproduced in the laboratory on similar constructions. In this way the effect on the heat-flow cycle of such factors as sudden cloudiness, scattered clouds, showers and shading of walls and roofs by other buildings can be studied. The method is also applicable for studying the relation between the physical and thermal properties of insulations on the heat transfer for transient or cyclic temperatures.

The cyclic temperature effects during the heating season are not as important as during the cooling season. There are, however, conditions that arise that might be investigated. During the winter sudden temperature changes due to storms or sunshine on walls and roofs, impose severe temperature cycles badly disrupting the assumed steady heat flow. These could also be investigated by providing sufficient cooling in chamber (A) facing the outside of the wall and reproducing the cycle with the unshielded lamps.

It should be noted that in cases where the resistance of the wall to heat flow is very low and the peak of the imposed temperature cycle is high the heat resistance of the standard blank must be reduced accordingly. There must always be as much or more heat input to the guarded box (D) under steady state as flows through the panel with the peak flow, otherwise the temperature within the guarded box (D) will build up with a summer cycle.

It is also possible to test roof sections in the vertical position if they do not contain air spaces. The temperature gradient on the guarded box side of the test section is made very small by locating the heaters at the bottom of the boxes. On the cycle side the surface temperature is made the same all over with the fans. If there are air spaces within the roof, the test panel and apparatus would have to be inclined to a position corresponding to that for which the field temperatures were taken.

If sunshine is a factor which determines the temperature cycle to be imposed on the outside of the wall, this method cannot be used unless the wall is opaque. The short wave length solar radiation which passes through such materials as glass cannot be produced in the laboratory. If windows are shaded by an awning from direct sun radiation they may be exposed to considerable re-radiated and solar energy from surrounding objects. This condition

can be investigated in the apparatus described.

Acknowledgments

The authors wish to acknowledge the assistance given them by the U. S. Navy, for whom the apparatus and test method herein described were developed. The assistance given by E. R. McLaughlin, research assistant, Engineering Experiment Station, The Pennsylvania State College, in making these tests is also acknowledged.

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Trends in Air Conditioning

By L. Gale Huggins*

Significant trends in the air conditioning industry during the past year point toward bigger "package" units, more automatic operation, and accelerated replacement of old slow-speed compressors. In addition, today's installations are notably more compact and reliable than ever before. As in previous years, weight and space per ton of cooling have continued to shrink as the result of continual engineering progress.

Modernizations Pay Out of Savings

There is a definite trend toward replacement of old slow speed compressors with modern high speed economically operating units. Such replacements show a reduction of installed horsepower and operating cost, greatly reduced maintenance, and increased reliability.

Solve Water Difficulty

City water for condensing purposes is becoming limited in certain cities occasionally because present water systems are too small to meet the many increased demands of which air conditioning is only one, or more frequently due to ordinances limiting the use of water or establishing rates that make city water for condensing expensive. To meet this condition, evaporative types of condensers have been developed to a point where they are very reliable and require little maintenance. They require only 2% to 5% of the water required for water-cooled condensers. In many cases the use of an evaporative condenser allows the system to be operated at a lower average condensing pressure, thus allowing a saving in power for the compressor motor which may more than offset the power required for the evaporative condenser pump and fan.

The trend of a number of leading manufacturers is now definitely toward more compact precision built machines operating at higher rotational speeds.

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Decade of Improvements

The last 10 years have seen many new developments for air conditioning. Prior to 1930, refrigeration machinery for air conditioning, as such, was non-existent. Machinery developed for ice making and cold storage was utilized to cool water for spray type air washer dehumidifiers. Some direct expansion systems employing high pressure, smooth steel tube CO_2 evaporators had been installed. The heavy, slow speed, bulky, manually operated machinery was expensive to build, install, maintain and operate. A full time operating engineer was required in constant attendance. These factors combined to limit the use of air conditioning to a few large theaters, a very few hotel dining rooms, and to certain industrial applications where a controlled atmosphere was absolutely essential to production.

The present popular use of air conditioning was unknown and almost unthought of. Aside from a few theaters in large cities, most people were denied the comfort it brings. Thousands of smaller theaters, all kinds of stores, shops, and restaurants were denied the since-proven advantages of increased business and profits air conditioning makes possible.

About 10 years ago, engineers began to study the problems involved in providing automatic air conditioning systems that could be installed in space available without seriously displacing revenue producing sales or other valuable space. Several fundamental requirements were recognized and have been met. For example, present day machinery for air conditioning now:

1. Takes minimum space.
2. Can be installed in existing buildings, basements or on upper floors without extensive building alterations.
3. Is automatic in operation; requires infrequent inspection and service.
4. Is absolutely safe both in normal and emergency operation.
5. Is economical in first, and operating cost.
6. Is factory built as far as practical, reducing the interruption of usual business during installation.

Operating Results of a Residence Radiant Wall Heating System

By E. J. Rodee*, New Haven, Conn.

SUMMARY—The operating results of a radiant wall heating system, with units concealed in outside and inside walls, are reported for a residence. The wind movement appreciably affected the heat loss, but the effect of sunshine showed no significant influence in cost of operation. It is concluded that a wall heating system can be installed in the outside walls of a house without increasing the wall thickness and without more than a normal amount of insulation and the results will compare favorably with free standing radiators from the standpoint of operating cost. The system used differs considerably from the types that have been popular in the British Isles and continental Europe for a number of years.

It is noted that temperature difference between floor and ceiling is less when heat is supplied by the walls than when it originates from free standing radiators. In the charts presented, it will be noted that the air temperature near the ceiling remains constant with the wall heating system, between 75 and 76 F, regardless of the point on the heating cycle, while with radiator heating the air temperature near the ceiling is approximately 7 deg higher at the maximum point of the heating cycle than at the minimum point

Introduction

PANEL heating, or low temperature radiant heating, has been popular in continental Europe and the British Isles for some years, but only recently has such a method of heating received much consideration in this country. The majority of installations which have been made use either the floor or ceiling as the radiant surface, very rarely the side walls. However, it would seem that to assure maximum comfort to the occupants, heating the side walls might be more desirable. When the body is in a standing or sitting position a larger percentage of the area of the body is radiating directly to vertical surfaces such as the side walls rather than to the horizontal floors and ceilings. Clarence M. Woolley has, for many years, been fathering an interest in radiant heating. It was mainly because of his suggestion that a wall heating system was devised and a study made of its operation in a residence.

Description of Wall Heating System

This wall heating system was designed to heat the air in the stud space of either outside or inside walls, the air, in turn, heating the plaster which becomes the radiation surface. Cast-iron convector radiators were designed to fit between the studs and so arranged that by removing the base board the heating sections could be removed without disturbing the plaster.

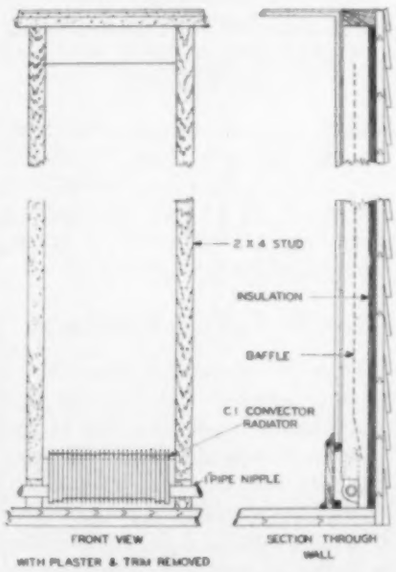

Fig. 1—Diagram of wall heating installation

These radiators were of two types, a double type section and a single type section. The double type was "L" shaped for use in inside walls while the single type was a straight vertical section with fins on one side only for installation in either outside or inside walls. These sections were 13 in. long and connected by 1-in. pipe nipples. Different length pipe nipples were used in connecting these sections to allow for variation in stud spacing. The single type section weighed 7½ lb and its heat emission rate was 2 sq ft of equivalent direct radiation, while the double type section weighed 14 lb and its heat output was 3½ sq ft of steam. In comparing the weights of these radiators with tubular type radiators, they were about 25 per cent less for the same heating effect.

A baffle was installed within the stud space behind and above the radiator to separate the upward and downward currents of air, and cause the air to circulate. Fig. 1 shows a section of a wall with the heating element and baffle in place. Fig. 2 shows a front view of a wall before the lath and plaster were applied. Fig. 3 shows convector radiator installed.

Prior to this installation, experiments had been made to determine the best type of lath for the heated walls. It was found that either rock

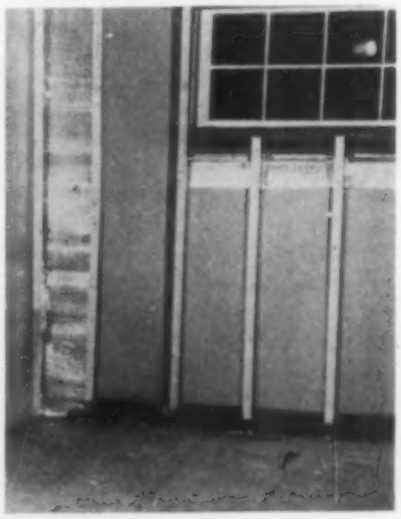

Fig. 2—Picture of wall showing convector radiators and baffle in place before lath and plaster was applied

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For presentation at the 47th Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Kansas City, Mo., January, 1941.

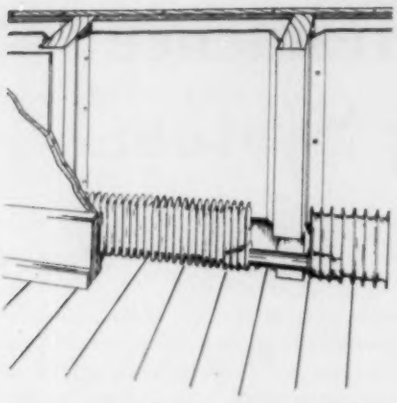

Fig. 3—Close-up view of convector radiator

lath or metal lath gave equally good results. The plaster used was a standard mix of lime and sand, and no special precautions were taken in its application. All the walls were papered after completion. The unusual feature of this installation was that steam instead of hot water was the heating medium. This was possible because the heating elements were not in direct contact with the plastered walls. The warm air within the stud space heated the walls uniformly and thereby caused no cracking of the plaster, as is sometimes the case where plaster is applied directly to the heating surface when pipe coils are used to convey the heating medium.

This heating system was installed in all the rooms of the first floor (except the kitchen) of a two-story frame house located in West Haven, Conn. The remainder of the rooms, including all the second floor, were heated with free standing radiators. Fig. 4 shows the exterior view of the house, and Fig. 5 is a first floor plan showing the walls which were heated. The building is a two-story structure with a basement and attic. The calculated maximum design heat loss of the building was 74,760 Btu per hour, using an outside temperature of —5 F, and an inside temperature of 70 F. The design heat loss by conduction was 57,200 Btu per hour and 17,560 Btu from air infiltration. The second floor ceiling was insulated with 4-in. mineral wool between the joists and there was no floor in the attic, giving a coefficient of 0.08 Btu per square foot per hour per degree Fahrenheit temperature difference. The side walls, except those used for heating, were of the usual frame construction, uninsulated, with a coefficient of heat transmission of 0.26. The heated side walls were insulated with 3 layers of aluminum foil mounted on corrugated asbestos paper attached to the sheathing facing the stud space. This gave a coefficient of 0.16 between the air in the stud space and the outside and 0.125 between the room air and the outside. More insulation would have been desirable, but this was the maximum amount which could be installed in a 4-in. stud space and still leave room for proper air circulation within the space itself.

The wall heating elements including the free standing radiators were

Fig. 4—House in West Haven, Conn., where wall heating studies were conducted

hooked up as a one-pipe steam system supplied with steam by an oil-fired steam boiler. The system was controlled by a heat-anticipating type thermostat mounted on an inside wall of the living room.

Test Method and Equipment

In order to make a direct comparison between wall heating and free standing radiators, the rooms which were equipped with wall heating were also equipped with radiators. These radiators were 3-tube, 23 in. high and 2½ in. from center to center of sections. The radiator heating system was used on alternate weeks during the test period. All the radiators and the wall heating sections were equipped with tight closing valves so that when one system was in use, the other could be shut off.

The oil supply to the burner was so arranged that daily oil weights could be taken. These weights were taken near midnight so that any sun effect on the structure would have been dissipated. Duration and number of cycles of burner operation were recorded. Inside temperature and humidity were automatically recorded in the various rooms in the house.

The outside weather conditions were recorded by a combination temperature and humidity recorder located about 20 ft from the north side of the house and 6 ft above the ground. Wind movement was recorded by a three-cup anemometer 6 ft above the peak of the roof and connected electrically to a counter in the basement. The number of hours of sunshine were taken from records of the U. S. Weather Bureau Station, New Haven, located about 5 miles north of the house under tests. Inside wall surface temperatures were measured by a thermopile, and air temperature gradients were measured by iron-constantan thermocouples, using a portable potentiometer accurate to ±0.2 F.

Periodic checks were made on the boiler burner unit to make certain that the efficiency of the unit did not change. These measurements consisted of flue gas analysis, flue gas temperature, and draft measurements. The flues of the boiler were inspected regularly and cleaned when necessary.

Test Results

The two curves for the two methods of heating, giving the daily oil consumption plotted against indoor-outdoor temperature differences, are shown in Fig. 6. It will be noted that the fuel oil consumption is approximately the same for the two methods of heating. Fig. 7 shows the fuel consumption per 24 hours per degree temperature difference between inside and outside, plotted

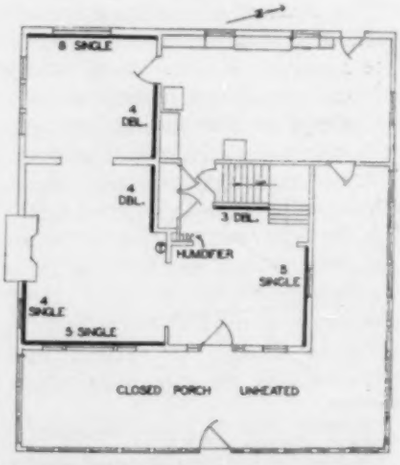

Fig. 5—First floor plan showing heated walls and number and type of convector radiator sections in each wall

against miles of wind movement per 24 hours. Both curves have the same slope and the fuel oil consumption is increased 0.3 lb per degree difference in temperature per 24 hours for an increase of 100 miles of wind movement per 24 hours. The curves in Fig. 8 are the same as shown in Fig. 6 except that all the points are corrected to 200 miles wind movement (approximate average wind movement of all tests) per 24 hours. This shows that the wall heating system required about 4 per cent more fuel than the system using free standing radiators, when corrected for outdoor wind velocity. The reason this difference appears in these curves and not in Fig. 6 is because the average wind movement during the tests with radiator heating was greater than during the wall heating tests.

An attempt was made to determine the effect of sunshine on fuel consumption. This is shown by Fig. 9, where hours of sunshine are plotted against pounds of oil per degree difference in temperature, corrected to zero wind movement. While there is a definite trend of the points indicating that a slight saving (about 0.02 lb of oil per hour of sunshine per degree difference in temperature) is effected, the amount is so small and the spread of the points so great that this relation cannot be considered significant when compared with the wind effect.

The difference between the floor-ceiling temperature gradients is shown by the curves in Fig. 10. The first set shows the minimum temperatures in the middle of the living room, just before the air temperature begins to rise. These temperatures occurred after the thermostat called for heat and at the instant steam came to the radiator inlet. The second set shows the maximum temperature occurring in the heating cycle taken at the same location. The last set of curves shows the average air temperatures at the different levels during several heating cycles. These temperature readings

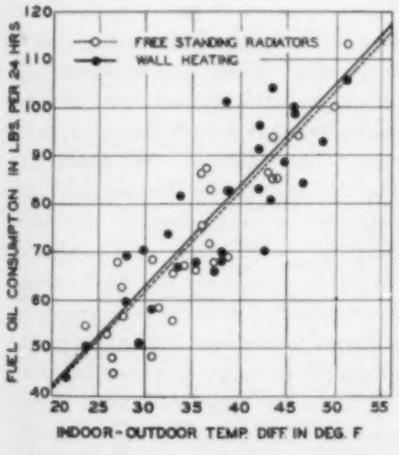

Fig. 6—Fuel oil consumption for wall heating system and free standing radiators without correction for difference in outside wind movement

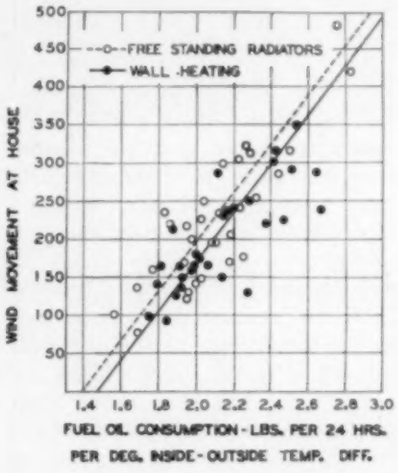
FREE STANDING RADIATORS
WALL HEATING
WIND MOVEMENT AT HOUSE
FUEL OIL CONSUMPTION - LBS. PER 24 HRS. PER DEG. INSIDE - OUTSIDE TEMP. DIFF.

Fig. 7—Effect of wind movement on fuel consumption

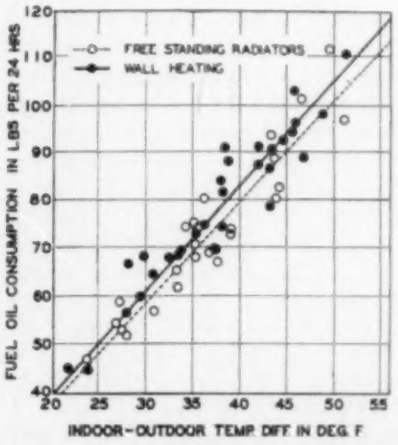

Fig. 8—Fuel oil consumption for wall heating and free standing radiators after correcting all points to 200 mile wind per 24 hours

were taken every two minutes, then averaged so that they gave an average temperature in respect to time and not an average between maximum and minimum temperatures. The thermostat setting remained the same for all tests with the two different methods of heating. However, in order to maintain the same feeling of comfort it was found necessary to maintain a 2 F higher air temperature with the radiator heating as compared with the wall heating. Fig. 11 shows how lowering the inside air temperature 2 F with the wall heating method would affect the fuel oil consumption when compared with the fuel oil required for heating with free standing radiators under the same outdoor weather conditions. While to be correct these curves should have been plotted with fuel oil consumption against outdoor temperature, they were plotted using the same difference between indoor and outdoor temperatures as in Fig. 8, so that these two sets of curves could be compared. The difference in the air temperatures at the lower levels, as shown by the curves in Fig. 10, may easily account for part of the difference in the feeling of comfort.

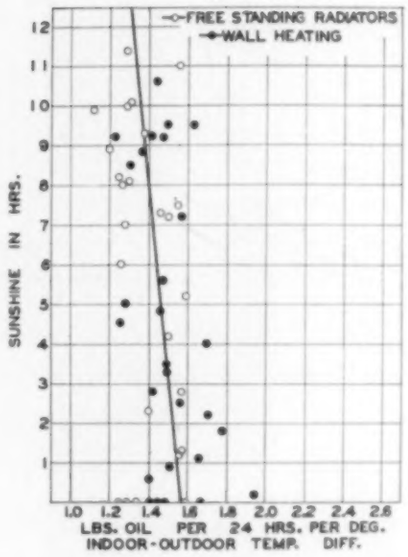

Fig. 9—Effect of sunshine as recorded by the U. S. Weather Bureau on fuel oil consumption

Fig. 12 is a group of curves showing wall surface temperatures taken at different levels from floor to ceiling. These curves show the changes in temperature of the wall surfaces during a heating cycle.

Summary

Wind movement appreciably affected the heat loss or the fuel consumption of the house in which the tests were conducted, and would lead one to believe that, in conducting tests in which the heat loss of a structure is the controlling factor, wind velocity readings are necessary.

The saving of fuel as affected by sunshine on this house was not sig-

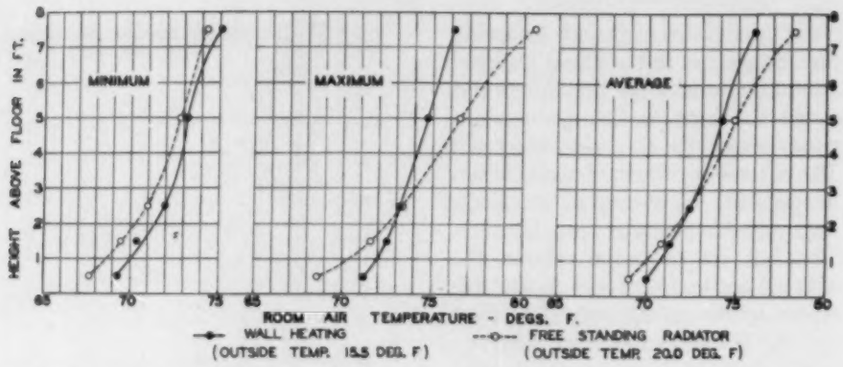

Fig. 10—Comparison of air temperature gradients during different phases of a heating cycle between wall heating and free standing radiators

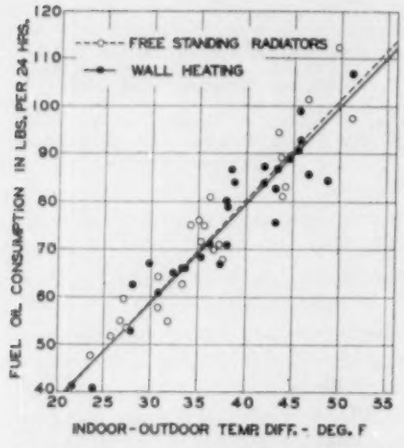

Fig. 11—Fuel oil consumption for wall heating and heating with free standing radiators after correcting to the same comfort conditions

nificant if the hours of sunshine, as recorded by the Weather Bureau, are taken as an index of the heating effect of the sun; but this factor, of course, ignores the intensity of sunshine.

A wall heating system can be installed in the outside walls of a house without increasing the wall thickness and without adding more than a normal amount of insulation, and still compare favorably with free standing radiators from a standpoint of cost of operation.

While no appreciable saving in fuel was noted by this study, it must be borne in mind that all the wall heated rooms were on the first floor beneath a heated space. If an unheated attic had been above these rooms, the lower temperature gradient obtained with the wall heating system might have effected a fuel saving.

The temperature difference between floor and ceiling is materially less when heat is supplied by the walls than when heating with free standing radiators. The air temperature near the ceiling remains nearly constant with the wall heating system, between 75 and 76 F, regardless of the point on the heating cycle, while with radiator heating the ceiling air temperature is approximately 7 deg higher at the maximum point of the heating cycle than at the minimum point.

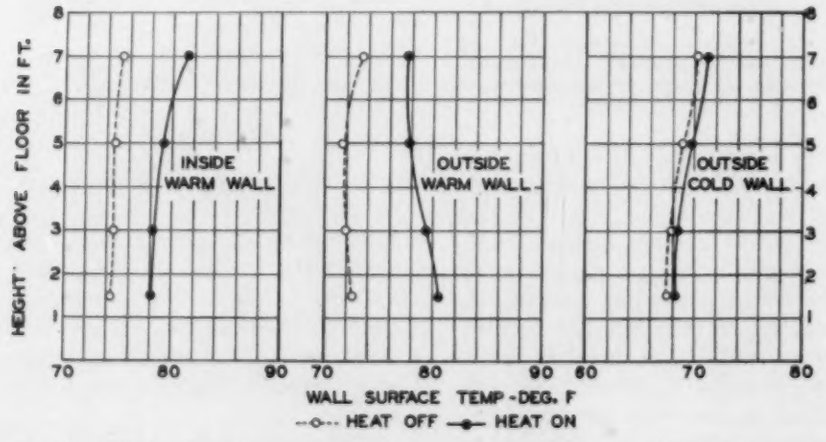

Fig. 12—Surface temperatures of different walls when heating with a radiant wall heating method

Membership and Meetings

By Neil D. Adams*

It is always interesting to learn the reasons that prompt the members to join the Society and how they evaluate Society membership. Possibly, the greatest inspiration comes from attendance at meetings and all testify that their presence at Annual and Semi-Annual Meetings has amply repaid them for the information they obtained and the contacts and lasting friendships that they have made.

There are benefits in membership for the experienced engineer, who may have achieved some success and distinction in the field of heating, ventilating and air conditioning, as well as for the young engineer who is starting out in the profession. The Society presents opportunities for technical advancement and personal development. Association with its members gives inspiration, stimulation and satisfaction to those who participate.

Since 1895 a roll call of the leaders in the profession and industry will find most of them identified with the Society and all have given freely from their experience to make the Society an outstanding engineering organization.

The Society has reached this point because it has not been content to accept and organize existing theories and data alone, but it has sponsored and operated its own Research Laboratory and with the close cooperation of other research institutions, it has collected and tabulated new and vital fundamental information. The success of the Society and its influence is evidenced by the fact that its publications are standard reference works for the profession. A member of the Society receives a large return on his investment, when his primary purpose in joining is to be associated with those who are enthusiastic and capable of advancing the profession to higher standards.

*Member of Council and Chairman, Membership Committee.

Pittsburgh Experiment Station of the U. S. Bureau of Mines where the Research Laboratory of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS is located

Comfort Requirements for Low Humidity Air Conditioning

By F. C. Houghten*, H. T. Olson** and S. B. Gunst***

Pittsburgh, Pa.

This paper is the result of research sponsored by the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS and the *American Gas Association*

THE evaluation of summer cooling and air conditioning requirements has been under consideration for the past several years by the Research Laboratory of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS. The studies[1-6] to date have dealt with the determination of these requirements with moderate relative humidities and for persons of varying ages, both sexes, and in different geographical locations. In most cases no particular effort was made to maintain any specified relative humidity, but percentages ranging from 40 to 80, with the maximum number of tests at about 50 per cent, have prevailed.

Recently the Committee on Research developed plans for a study designed to give comfort requirements for persons in what is generally known as the low humidity field. This paper reports the results of the Laboratory's study at 30 per cent relative humidity with some comparison in the higher humidity conditions, and a few exploratory tests in air conditions having humidities as low as 15 per cent. The study was made in the psychrometric rooms of the Laboratory in Pittsburgh under the direction of the Technical Advisory Committee on Sensations of Comfort† and much the same technique as that reported[1, 2, 7] in earlier studies was employed.

In order to make it possible to maintain the desired low humidities during the heat of the summer, a conditioning unit utilizing a dehydration agent was installed in connection with each of the two psychrometric rooms. A diagrammatic sketch showing the relation between one of the two psychrometric rooms, the conditioning equipment, and a number of pertinent arrangements in the room is given in Fig. 1. Return air from the room passed through the dehumidifying unit where its moisture content was reduced and its temperature raised. The hot, dry air then passed over cooling coils (through which water cooled by a 4-ton ammonia refrigerating plant was circulated), then over direct expansion dichlorodifluoromethane coils supplied with refrigerant from a 2-ton compressor, through a blower and finally into the plenum chamber of the psychrometric rooms where it passed over thermostatically-controlled electrical heating coils of sufficient capacity to give a 5 degree temperature rise. In order to maintain the moisture con-

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[1-6]See Bibliography.

For presentation at the 47th Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Kansas City, Mo., January 1941.

†ASHVE Technical Advisory Committee on Sensations of Comfort: Thomas Chester, *Chairman*, C. R. Bellamy, E. P. Heckel, W. S. Kilpatrick, Dr. W. J. McConnell, A. B. Newton, B. F. Raber, C. Tasker, L. C. Soule.

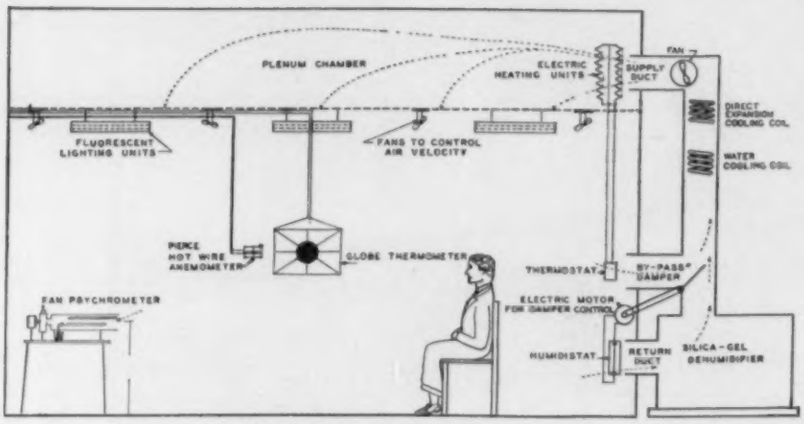

Fig. 1—Diagrammatic sketch of one of the two psychrometric rooms, showing arrangement of conditioning system, controls, location of one of subjects in the room, and other pertinent arrangements

tent of the air in the psychrometric rooms at the desired level, a humidistatically-operated by-pass damper controlled the volume of room air passing through the dehumidifier. Thus it was possible to control independently the moisture content and the dry-bulb temperature of the air. With this arrangement, relative humidities of 30 per cent could easily be maintained during the most severe summer conditions with 6 persons in the room. Minimum relative humidities of from 15 to as low as 12 per cent could be obtained with some difficulty on less humid days with 5 persons in the room.

Male subjects between the ages of 18 and 21 years were selected after complete physical examinations by a practicing physician and mental classification by psychological tests[9] of general intelligence, resulting in the selection of a group of men of uniform intelligence and physiological make-up. Four of these subjects were used in most of the tests, while four men and four women of varying ages served as subjects in a few final tests in order to compare the results obtained with those of the trained subjects.

Preparatory to running the tests, the physiological-psychological conditions in the psychrometric rooms were improved by replacing the old tungsten lights with five fluorescent lights in each room, giving a uniformly distributed illumination of 15 foot-candles. Small circulating fans were installed in each room, giving a uniform air movement of 24, ±3, fpm throughout the occupied zone. Each room was equipped with an electric globe thermometer, to give the mean radiant temperature. In this new instrument, which is more fully discussed in another Laboratory report,[7] the globe-air temperature difference is determined directly by an 8-junction differential thermocouple with alternate junctions in the globe and in the surrounding air. A Pierce hot-wire anemometer gave the air velocity near the globe.

The globe-air temperature differential varied throughout the tests from 0.3 to 1.3 deg. The observed variations in the mean radiant temperature ranged from a low of 0.5 deg above air temperature to a high of 2.4 deg above air temperature, and the average over all tests was 1.4 deg above air temperature. The mean radiant temperature is a measure of the environmental effect of radiation and implies the integrated average temperature of all surfaces within view of the point under consideration.

A recent Laboratory study[7] indicates that for a condition of 70 deg ET and 30 per cent relative humidity a 2 deg elevation or drop in the mean radiant temperature above or below the air temperature will about compensate for a 1 deg decrease or elevation in the effective temperature of the air. It will be observed, therefore, that the mean radiant temperature prevalent in the test room throughout this study should rarely affect the environmental condition in the room by more than what would be had with a 0.7 deg change in effective temperature. Obviously, the mean radiant temperatures in the rooms were elevated by the higher skin and clothing temperatures of the occupants, by the lights, and by wall surfaces having slightly elevated temperatures due to the inflow of heat to the rooms. Since in this summer's study the room was always cooled below the surroundings, there were never any surfaces in the room in view of the globe that were at a lower temperature than the air.

The above alterations in the psychrometric rooms and equipment served to improve conditions therein by decreasing the *mean radiant temperature — air temperature difference* and by giving a more uniformly controlled air velocity. Since the globe thermometer means of measuring the mean radiant temperature has only recently been available it was not used in the earlier studies. However, a study of conditions within the rooms before these changes were made indicates that in former studies the mean radiant temperature may at times have been as high as 4 deg above the air temperature having an effect equivalent to a maximum of 2.0 deg ET.

Test Procedure

In conducting a given test, the rooms were conditioned to the desired effective temperature and relative humidity for a period of 3 hours before the subjects entered from the prevailing outside condition, when the test started and continued for from 3 to 4 hours. Just before en-

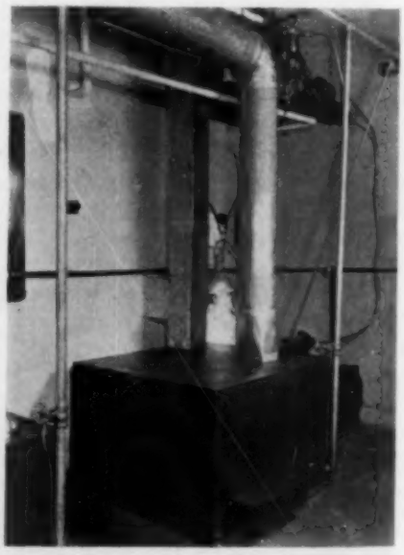

Fig. 2—View of air conditioning equipment used in tests

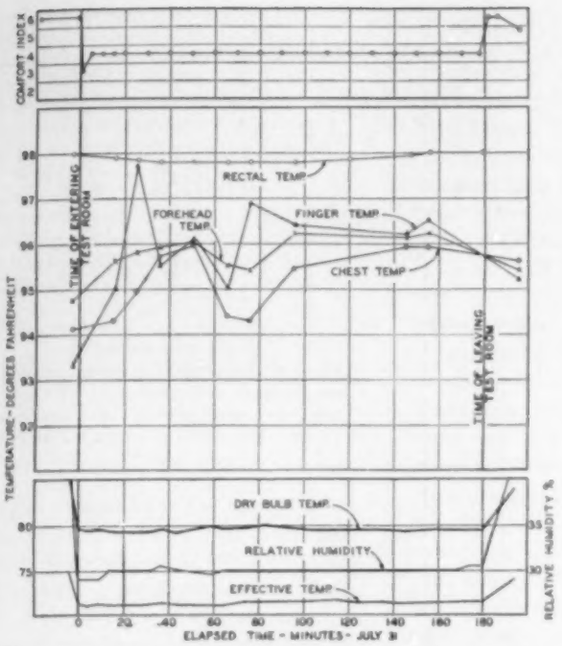

Fig. 3—Log of atmospheric conditions maintained in one test and physiological reactions of one subject while ideally comfortable

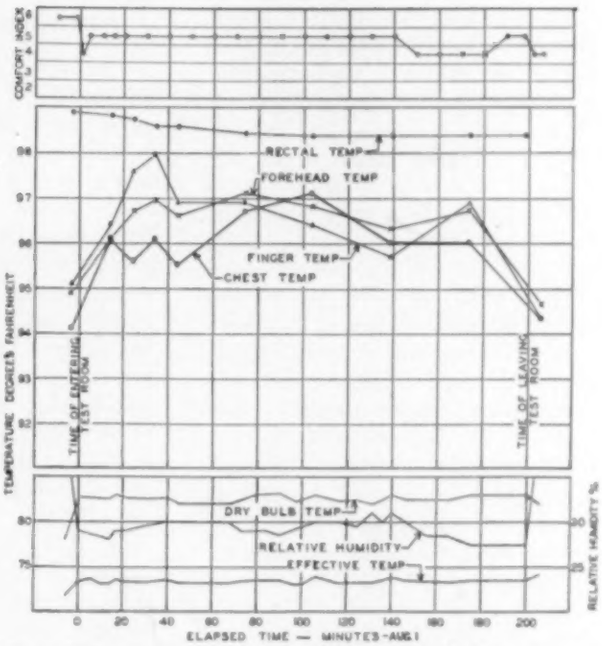

Fig. 5—Log of atmospheric conditions maintained in one test and physiological reactions of one subject while warm

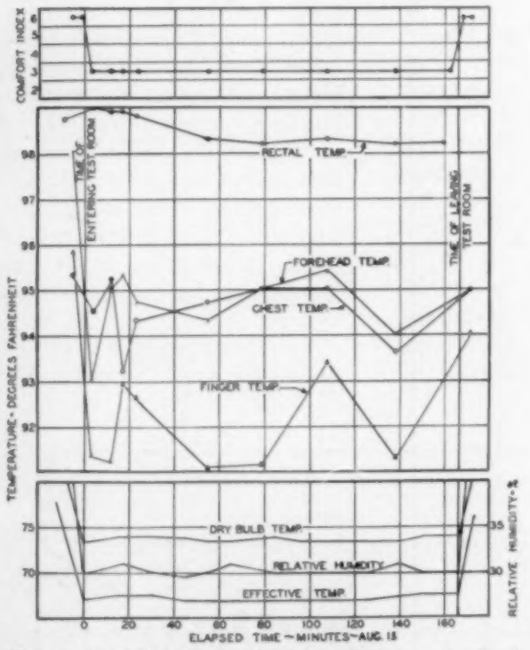

Fig. 4—Log of the atmospheric conditions maintained in one test and physiological reactions of one subject while cool

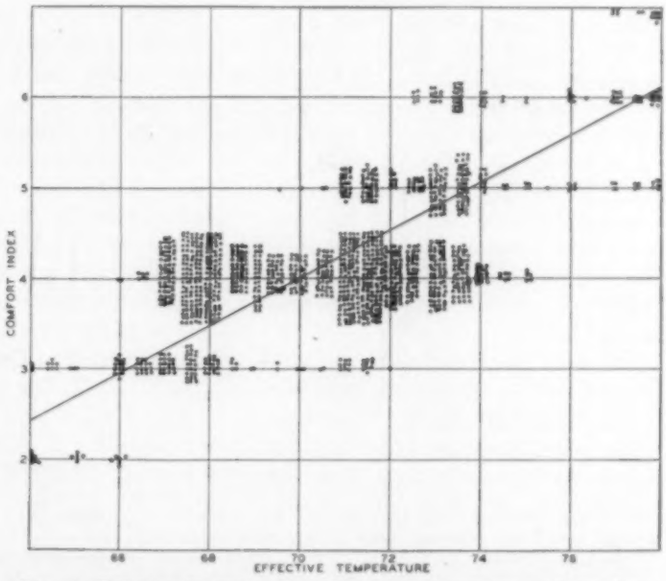

Fig. 6—Relation between the effective temperature and comfort votes of subjects in tests at 30 per cent relative humidity

tering the test room, the pulse rate, degree of perspiration, feeling of warmth, body temperature, and the skin temperatures of the index finger, the chest and forehead of each subject were observed. These same observations were again made immediately after entering the room; the feeling of warmth first, and the other observations as rapidly as possible thereafter. Throughout the test period the feeling of warmth and the degree of perspiration of each subject were recorded every 15 min, while his other physiological reactions were determined at less frequent intervals. At the close of the test the subject again re-entered the outside, immediately reporting his feeling of warmth.

The subjects expressed their feelings of warmth in accordance with the index used in the earlier studies at the Laboratory; that is, *4* indicated a feeling of ideal comfort; *3* and *5*—comfortably cool and comfortably warm, respectively; *2* and *6*—cool and warm, respectively; and *1* and *7*—cold and hot, respectively. The degree of perspiration was observed in accordance with an index wherein *0* represented freedom from perspiration; *1* clammy; *2* damp; *3* surface entirely covered with perspiration or standing in beads or droplets; *4* perspiration runs and drips or soaks through clothing.

Skin temperatures were taken by means of No. 36 copper-constantan

thermocouples mounted on cork buttons which were held on the skin so that the exposed junctions were in direct contact with the skin.

Test Data

Twenty-six tests were conducted at 30 per cent relative humidity with constant effective temperatures ranging from 64 to 78 deg for the different tests. A few of the early tests at 30 per cent relative humidity were made with the effective temperature ranging from a low value at the beginning of the test when the subjects were *cool* through a condition where they were *comfortable* to one where they were *warm*, after which the temperature was again slowly returned to the original condition. In other tests this cycle was reversed. These tests served to give a quick survey of the entire range but their results were not interpreted as giving the optimum condition with as great accuracy as the greater number of tests in constant atmospheric conditions. A few tests were conducted with relative humidities as low as could be had (usually from 12 to 15 per cent) with four subjects and one observer in the room. Additional tests were made at 70 per cent relative humidity in an attempt to establish a control comparison with earlier Laboratory studies.

Logs of three tests on one subject when the conditions were respectively comfortable, somewhat cool, and somewhat warm for his comfort are given in Figs. 3, 4, and 5. Figs. 6 and 7 give the results of 26 tests at 30 per cent relative humidity and 13 tests at 70 per cent, respectively, while Fig. 8 gives the relation between the effective temperature of the conditions in the different tests and the percentage of votes for *ideally comfortable*, for *comfortably cool* and *cool* combined, and for *comfortably warm* and *warm* combined. The relation between the effective temperature of the condition and the observed finger, chest, and forehead temperatures is plotted in Figs. 9, 10, and 11, respectively. Curves are drawn for the chest and forehead temperatures which for comparison are superimposed on the finger temperature chart.

Discussion of the Results

The logs of the three tests on one subject, Figs. 3, 4, and 5, show the same characteristics of data found in earlier studies. The careful observation of body, and skin temperature of the forehead, finger and chest brought out one fact with greater conclusiveness than in previous studies—that is, when the subject was *cool* his index finger temperature dropped considerably below that indicated for his forehead and chest. This effect was quite universally indicated by the tests in this study. Whenever a subject had a feeling of coolness, particularly if this feeling persisted for some time, his finger temperature showed a decided drop. It was further observed by questioning the subjects and observing their data that this drop in finger temperature usually accompanied a more than casual sense of coolness and was expressed by the subjects as *a feeling of cold all the way through himself*, or as *feeling cold in his bones*. This observation is more or less in agreement with the findings of Sheard.[8]

The relationships between skin temperature and the effective temperature of the condition are better shown in Figs. 9 to 11. There is no apparent separating out of the skin temperature points for the different subjects indicated by the different symbols. Considerable variation is shown for the points in the three figures. They indicate in general, however, a drop in skin temperature with atmospheres of lower effective temperature. The relations for the chest and forehead skin temperatures are somewhat consistent and representative curves are drawn. These curves, superimposed on Fig. 9, show that while the chest and forehead skin temperatures do not differ greatly from each other they are both considerably higher and much less erratic than the finger temperatures. It will be noted that the finger temperatures became particularly erratic for cool atmospheres, occasionally falling to very low values as indicated by the points shown to fall below the minimum finger temperature ordinate of 84 F.

The data plotted in Figs. 6 and 7 show the usual characteristics for

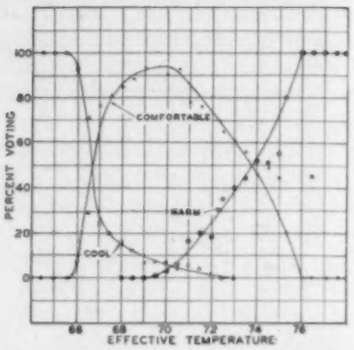

Fig. 8—Relation between effective temperature and percentage of subject votes for comfortable (4); for cool (2 and 3); and for warm (5 and 6)

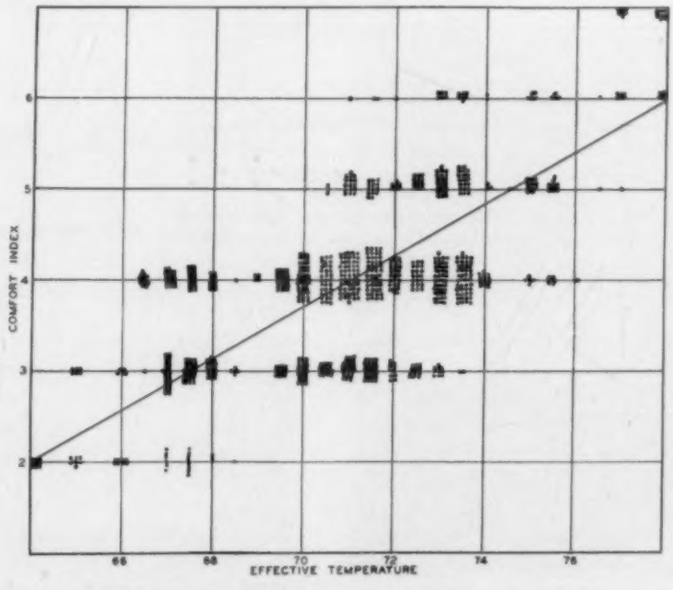

Fig. 7—Relation between effective temperature and comfort votes of subjects in tests at 70 per cent relative humidity

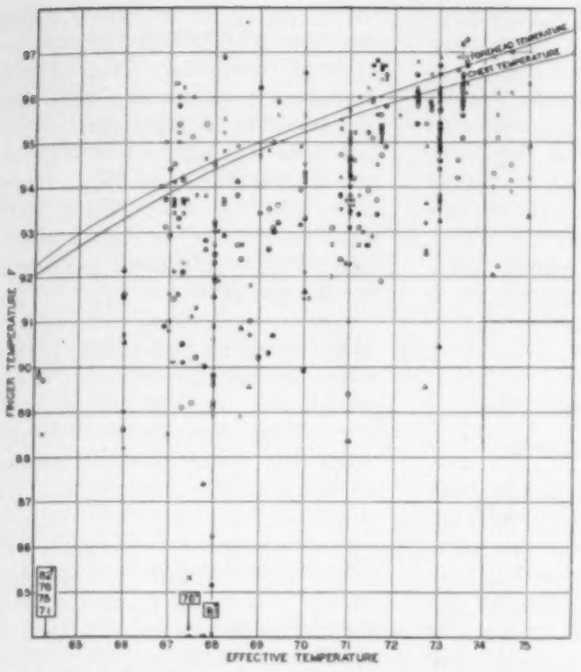

Fig. 9—Relation between effective temperature of atmospheric condition and index finger skin temperatures of the subjects. The chest and forehead temperature curves from Figs. 10 and 11 are superimposed

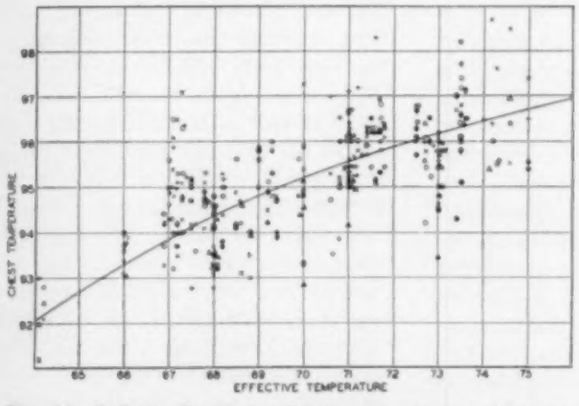

Fig. 10—Relation between effective temperature of atmospheric conditions and chest skin temperatures of subjects

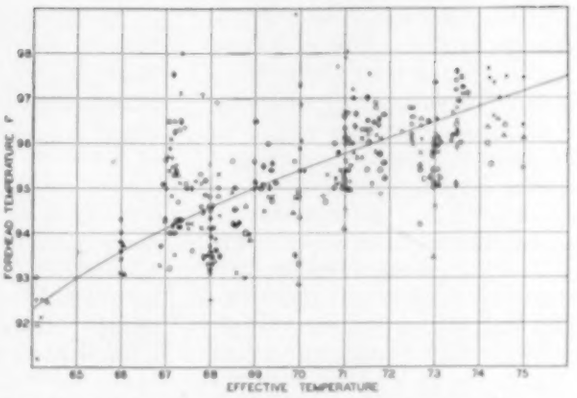

Fig. 11—Relation between effective temperature of atmospheric conditions and forehead skin temperatures of subjects

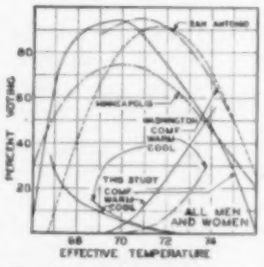

Fig. 12—Relation between effective temperature and percentage of ideal comfort except where otherwise indicated. Curves for this study (30 per cent RH), Washington, Minneapolis, and San Antonio

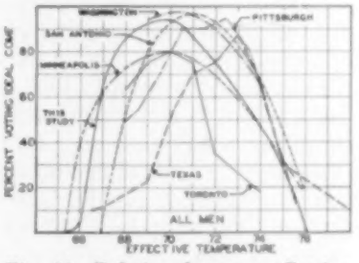

Fig. 13—Relation between effective temperature and percentage of comfort for all men for this study (30 per cent RH), Washington, San Antonio, Minneapolis, Pittsburgh, Toronto, and Texas

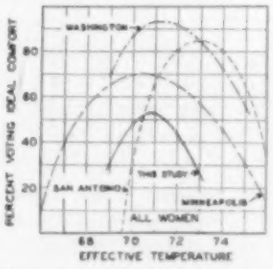

Fig. 14—Relation between effective temperature and percentage of comfort for all women for this study, Washington, San Antonio, and Minneapolis

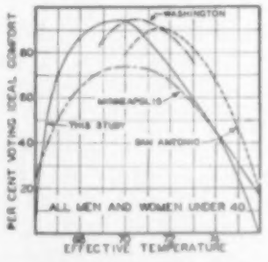

Fig. 15—Relation between effective temperature and percentage of comfort for all men and women under 40 for this study (30 per cent RH), Washington, San Antonio, and Minneapolis

studies of this type and indicate optimum comfort at 70 deg ET with 30 per cent relative humidity, and at 71 deg ET with 70 per cent relative humidity. The plotting of the percentage votes for 30 per cent in Fig. 8 further shows optimum comfort to be at 70 deg ET with the usual falling off at lower or higher temperatures. The more rapid drop in the curve for low temperatures than is the case for high temperatures has been shown in earlier Laboratory studies to be characteristic.

The 70 deg ET indicated for comfort at 30 per cent relative humidity when compared with the optimum point of 71 deg ET for 70 per cent in this study might be construed as indicating that a slightly lower temperature is necessary for comfort at low humidities. If this were conclusively proved it would indicate that the slope of the effective temperature lines in this temperature range are slightly in error. Previous studies, as indicated in Figs. 12 to 16, show a certain degree of variation in the effective temperature required for optimum percentage of comfort in the different studies in different geographical

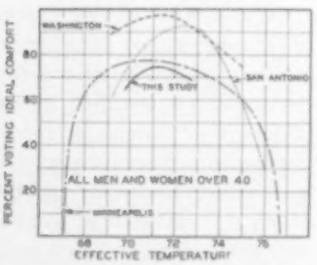

Fig. 16—Relation between effective temperature and percentage of comfort for all men and women over 40 for this study, Washington, San Antonio and Minneapolis

locations on men and women of different age groups. The variations in effective temperature do not however correlate particularly well with any of these differences and it is quite possible that the one degree difference here indicated may not be significant. These different studies appear to show a more positive correlation between the effective temperature for comfort and the severity of heat of the summer. Thus, the low optimum temperature found in this study may possibly be accounted for by the less severe heat of the past summer. A log of the maximum daily temperatures observed by the Pittsburgh Weather Bureau during the period included in this study is given in Fig. 17. It will be seen that a maximum of 90 F was exceeded only 15 times and that the highest maximum was 96 F. An analysis of the daily variation in the optimum condition desired for comfort in relation to the outside temperature showed no consistent variation.

The few tests with other than trained subjects, including men and women of different age groups, show the same general tendencies found in earlier studies as plotted in Figs. 12 to 16. Women and persons over 40 show a desire for slightly higher temperature.

The comparison of all curves in Figs. 12 to 16 adds further proof to the point brought out in a previous study[5] that with all the variations in geographical location, sex, and age, and now the addition of relative humidity, the variation in the effective temperature requirements for optimum comfort is relatively small, ranging from 70 to 73 deg. The greatest single factor in this variation seems to be latitude or more likely prevailing summer conditions.

The curves in Fig. 18 giving, by their intersection with the *comfort 4* ordinate, the effective temperature for optimum comfort, and by their slopes the change in the effective temperature necessary to give a single index change in the feeling of warmth, for various studies made by the Laboratory since 1923, including this study, are of interest. They show the variations in effective temperature required for comfort not only with summer cooling and air conditioning but also with winter heating and air conditioning. With the exception of the first study made in 1923, optimum comfort is indicated to range from 67.5 to 73 deg ET. Also, with the exception of the first study, the slope expressed in degrees effective temperature for a unit change in the comfort index indicates that from 2.3 to 4.3 deg ET change is required for a unit comfort index change or a change from *ideally comfortable* to *comfortably warm*.

Drafts, Shock and Other Peculiar Sensations

Analyses of the reactions to draft, sense of coolness, and other local sensations upon entering the rooms show no noticeable variation from earlier studies. No indications of a draft were recorded among the 1,627 times which the individual subjects were asked to record their reactions. This may be accounted for by the better control of air velocities in this study. An analysis of cold shock experienced upon entering the conditioned space shows no tendencies different from those found in earlier studies. A decisive feeling of coolness was experienced by the subjects upon entering the cooled space from the hot outside, particularly when the body was wet with perspiration. The severity and period of these experiences, however, show no measurable differences from those found in earlier studies, and the subjects usually indicated that the feeling of coolness was a pleasant rather than an unpleasant sensation.

The lower relative humidity at which this study was conducted led to including among the questions asked of the subjects those of indications of dryness of the lips, throat, or nose as well as dryness of the skin. There were four indications of dryness of the lips, and none of the throat, nose, or skin recorded among the 1,670 interrogations, indicating conclusively that no such sensations predominated at a relative humidity of 30 per cent. In the few tests conducted at relative humidities ranging from 12 to 15 per cent, however, there was a fairly decisive increase in such observations of dryness, usually applying to the lips and nose.

The warm shock experienced upon re-entering the hot outside after spending several hours in the cooled and air conditioned space showed no measurable difference from that found in earlier studies at higher relative humidities. There is considerable conjecture concerning the reasons for either the cold shock upon entering a cooled space or the warm shock upon leaving. Assuming that the air in a cooled space has both its temperature lowered and its moisture content decreased below that prevalent in the outside atmosphere, there are two factors affecting either shock sensation—namely, the temperature and the moisture content (or vapor pressure) of the air, in both the conditioned space and the outside. Before entering the cooled space, a person's body will be as nearly in equilibrium with the hot environment as can be realized by the ability of life to adapt itself to a given atmospheric condition. If the effective temperature is high for comfort, the body will be wet with perspiration, thereby encouraging the proper rate of evaporation of perspiration to eliminate the excessive body heat resulting from the prevailing temperature and vapor pressure of the atmosphere. Immediately upon entering a cooled space the body will not be in equilibrium with its environment—the availability of moisture on the body is excessive for the new environment and the vapor pressure of the atmos-

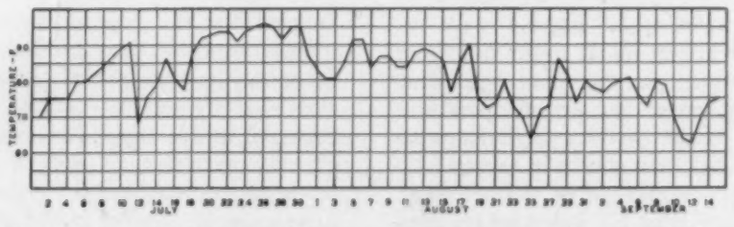

Fig. 17—Log of maximum daily temperatures reported by the Weather Bureau in Pittsburgh

phere is lower, both factors encouraging more rapid evaporation and therefore a higher rate of heat loss from the body. The fact that the conditioned atmosphere has the lower dry-bulb temperature will in some measure reduce evaporation for the reason that evaporation always requires the availability of heat from the surroundings—in this case, from the atmosphere and the body. The combined result of these three changes will be such as to increase the rate of evaporation until equilibrium has been re-established through a decrease in the amount of perspiration available. While the body, no doubt, very quickly exercises control in reducing the rate of perspiration a certain time must necessarily elapse before the moisture already on the body surface is reduced to equilibrium. Hence, while the sensible heat loss increases upon entering the conditioned space because of the greater *body surface temperature — air temperature* difference the latent heat loss also increases, resulting in an excessive feeling of coolness.

Upon re-entering the warm outside after the body has reached equilibrium with the inside, the reverse takes place. Within the conditioned space the body keeps latent heat loss down by limiting the availability of perspiration for evaporation, so that the combined sensible and latent loss results in equilibrium between the rate of heat production and heat loss. Upon entering the hot and humid outside, sensible heat dissipation is immediately reduced, and because of the higher vapor pressure of the atmosphere and the freedom from perspiration on the body, latent heat loss must also be reduced. As a result the person will have an excessive feeling of warmness until the body has again re-established the availability of perspiration on the surface so that in the new surroundings the latent loss will increase to re-establish a balance between total heat production and dissipation. Since availability of perspiration on the surface is the most important of the three factors, however, it is probable that perspiration on the surface before entering the cooled space and the lack of perspiration on the surface upon re-entering the warm outside conditions account for the greatest effect in the feeling of coolness upon entering and the feeling of warmness upon leaving the conditioned space.

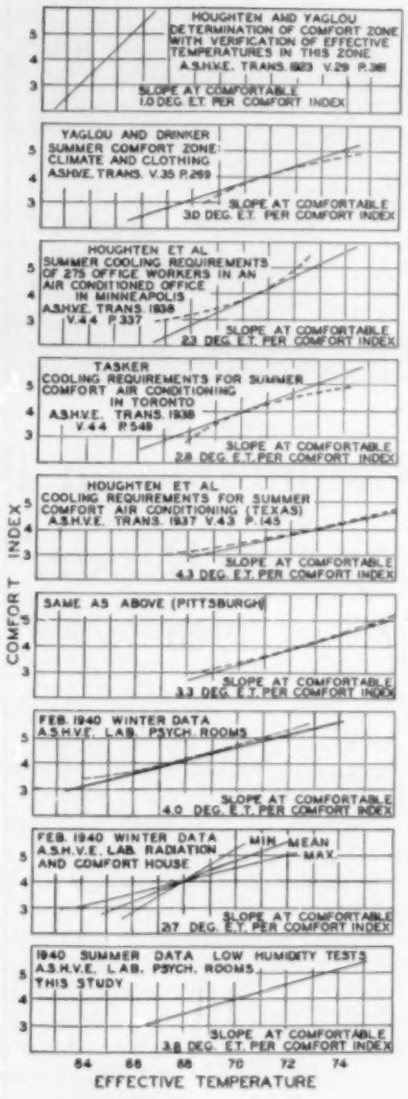
HOUGHTEN AND YAGLOU
DETERMINATION OF COMFORT ZONE WITH VERIFICATION OF EFFECTIVE TEMPERATURES IN THIS ZONE
A.S.H.V.E. TRANS. 1923 V.29 P.361
SLOPE AT COMFORTABLE 1.0 DEG. E.T. PER COMFORT INDEX
YAGLOU AND DRINKER
SUMMER COMFORT ZONE: CLIMATE AND CLOTHING
A.S.H.V.E. TRANS. V.35 P.269
SLOPE AT COMFORTABLE 3.0 DEG. E.T. PER COMFORT INDEX
HOUGHTEN ET AL
SUMMER COOLING REQUIREMENTS OF 275 OFFICE WORKERS IN AN AIR CONDITIONED OFFICE IN MINNEAPOLIS
A.S.H.V.E. TRANS. 1938 V.44 P.337
SLOPE AT COMFORTABLE 2.3 DEG. E.T. PER COMFORT INDEX
TASKER
COOLING REQUIREMENTS FOR SUMMER COMFORT AIR CONDITIONING IN TORONTO
A.S.H.V.E. TRANS. 1938 V.44 P.549
SLOPE AT COMFORTABLE 2.8 DEG. E.T. PER COMFORT INDEX
HOUGHTEN ET AL
COOLING REQUIREMENTS FOR SUMMER COMFORT AIR CONDITIONING (TEXAS)
A.S.H.V.E. TRANS. 1937 V.43 P.145
SLOPE AT COMFORTABLE 4.3 DEG. E.T. PER COMFORT INDEX
SAME AS ABOVE (PITTSBURGH)
SLOPE AT COMFORTABLE 3.3 DEG. E.T. PER COMFORT INDEX
FEB. 1940 WINTER DATA
A.S.H.V.E. LAB. PSYCH. ROOMS
SLOPE AT COMFORTABLE 4.0 DEG. E.T. PER COMFORT INDEX
FEB. 1940 WINTER DATA
A.S.H.V.E. LAB. RADIATION AND COMFORT HOUSE
MIN. MEAN MAX.
SLOPE AT COMFORTABLE 2.7 DEG. E.T. PER COMFORT INDEX
1940 SUMMER DATA LOW HUMIDITY TESTS
A.S.H.V.E. LAB. PSYCH. ROOMS
THIS STUDY
SLOPE AT COMFORTABLE 3.8 DEG. E.T. PER COMFORT INDEX
COMFORT INDEX
5
4
3
64 66 68 70 72 74
EFFECTIVE TEMPERATURE

Fig. 18—Relation between effective temperature and optimum comfort for subjects in various studies since 1923

Conclusions

While the study indicates a possible lower effective temperature requirement of 1 deg at 30 per cent relative humidity when compared with that at 70 per cent, this difference is barely significant, and the relatively low optimum effective temperature indicated may be attributed to the prevalence of relatively cool weather conditions during the past summer.

Bibliography

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2. ASHVE Research Report No. 1055—Cooling Requirements for Summer Comfort Air Conditioning, by F. C. Houghten, F. E. Giesecke, C. Tasker, and Carl Gutberlet. (ASHVE Transactions, Vol. 43, 1937, p. 145.)

3. ASHVE Research Report No. 1088—Summer Cooling Requirements of 275 Workers in an Air Conditioned Office, by A. B. Newton, F. C. Houghten, Carl Gutberlet, and R. W. Qualley. (ASHVE Transactions, Vol. 44, 1938, p. 337.)

4. ASHVE Research Report No. 1127—Reactions of Office Workers to Air Conditioning in South Texas, by A. J. Rummel, F. E. Giesecke, W. H. Badgett, and A. T. Moses. (ASHVE Transactions, Vol. 45, 1939, p. 459.)

5. ASHVE Research Report No. 1136—Summer Cooling Requirements in Washington, D. C. and Other Metropolitan Districts, by F. C. Houghten, Carl Gutberlet, and Albert A. Rosenberg. (ASHVE Transactions, Vol. 45, 1939, p. 577.)

6. ASHVE Research Report—Reactions of 745 Clerks to Summer Air Conditioning, by W. J. McConnell, B.S., M.D., and M. Spiegelman, M.E., M.B.A. (ASHVE Journal Section, *Heating, Piping and Air Conditioning*, May 1940, p. 317.)

7. ASHVE Research Report—Radiation as a Factor in the Sensation of Warmth, by F. C. Houghten, S. B. Gunst, and John Suciu, Jr. (For presentation at the 47th Annual Meeting of the American Society of Heating and Ventilating Engineers, Kansas City, Mo., January, 1941.)

8. ASHVE Research Report No. 1110—Skin Temperatures of the Extremities and Effective Temperature, by Charles Sheard, Ph.D., Marvin M. D. Williams, Ph.D., and Bayard T. Horton, M. D. (ASHVE Transactions, Vol. 45, 1939, p. 153.)

9. Otis Self-Administering Tests of Mental Ability, by Arthur S. Otis. (World Book Co., Yonkers, N. Y., 1922.)

AIR CONDITIONING ASSOCIATION WILL MEET IN CHICAGO

Announcement has been made that the 1941 convention of the *National Air Conditioning Association* is to be held at the Blackstone Hotel, Chicago, Ill., January 13 to 15.

According to the statement of J. W. Page, Jr., President of the Association, revision of the Association's By-Laws will be one of the major items of business to be considered at the meeting.

Pittsburgh Experiment Station of the U. S. Bureau of Mines where the Research Laboratory of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS *is located*

ASHVE Committee on Research Annual Report

1940

A. E. Stacey, Jr.
Chairman

C.-E. A. Winslow
Vice-Chairman

T. H. Urdahl
Executive Committee

B. M. Woods
Executive Committee

DURING 1940 the Society's research activities have resulted in the completion of nine laboratory projects and the initiation of eight new investigations at the ASHVE Research Laboratory and at cooperative institutions. This work has produced valuable scientific papers and reports contributing needed information on heating, ventilating and air conditioning to the engineering profession and to industry. Earlier in the year the available facilities of the research organization were offered by the President of the Society to the federal government for service in connection with the national defense program.

Completed laboratory investigations have dealt with the effect of radiation on the sensation of warmth of an occupant in an enclosed space, and reactions of individuals to environment having low relative humidities. Additional studies have also developed data for establishing heat gain through windows with various types of appurtenances; frictional flow of water in large size pipes; and comparative performance of air filters utilizing various methods of test. Among the new investigations which have been outlined and initiated are those dealing with noise transmission in ducts; heat losses from basements; air flow in duct transitions; and studies to establish basic design factors in radiant heating and cooling applications.

The research program was conducted through 23 Technical Advisory Committees, each responsible for reviewing, analyzing and improving through research the fundamental data in its particular field or scope. A total expenditure of $45,000 was spent by the Society on the various projects. Effort was made this year to clearly define the scope of the activities of each Technical Advisory Committee in order that the whole research program could be correlated to produce basic fundamental data.

The reports which follow give detailed information covering the committee programs developed for investigation either at the Research Laboratory or in cooperative institutions.

J. H. Walker
Technical Adviser

F. C. Houghten
Director

M. K. Fahnestock
Executive Committee

John James
Technical Secretary

Committee on Research

A. E. Stacey, Jr., *Chairman*

C.-E. A. Winslow, *Vice-Chairman* — F. C. Houghten, *Director*

J. H. Walker, *Technical Adviser* — A. C. Fieldner, *Ex-Officio Member*

One Year

M. K. Fahnestock — W. L. Fleisher — R. J. Tenkonohy

T. H. Urdahl — B. M. Woods

Two Years

R. E. Daly — W. A. Danielson — H. J. Rose

C. Tasker — C.-E. A. Winslow

Three Years

Philip Drinker — Axel Marin — A. E. Stacey, Jr.

J. H. Van Alsburg — J. H. Walker

Executive Committee

A. E. Stacey, Jr., *Chairman*

M. K. Fahnestock — T. H. Urdahl — C.-E. A. Winslow — B. M. Woods

Finance Committee

E. P. Heckel, *Chairman*

J. A. Goff — H. B. Hedges — J. A. Kiesling — C. H. Randolph

Technical Advisory Committees

Sensations of Comfort, 1

Thomas Chester, *Chairman;* **C. R. Bellamy, E. P. Heckel, W. S. Kilpatrick, Dr. W. J. McConnell, A. B. Newton, B. F. Raber, C. Tasker.***

This Committee work has progressed along the lines set forth in the annual report for 1939. Eleven papers dealing with indoor atmospheric conditions conducive to summer comfort in air conditioning enclosures have been reviewed. These papers cover information ascertained by the ASHVE Research Laboratory and in field tests at San Antonio, Washington, D. C., New York City, Minneapolis and Toronto.

A map has been prepared which shows the United States divided into four zones on the basis of July mean-maximum temperatures with corresponding recommended indoor effective temperatures of 70, 71, 72 and 73 deg in the order stated for the four zones from north to south. This map will be published subsequently along with a digest of information on summer comfort contained in the eleven papers previously mentioned.

Investigative work has been conducted during 1940 at the Research Laboratory to determine the effects of low relative humidities on comfort. A paper covering this work will be presented at the 1941 Annual Meeting.

Physiological Reactions, 2

C.-E. A. Winslow,* *Chairman;* **Dr. T. Bedford, Dr. E. F DuBois, Dr. M. B. Ferderber, E. P. Heckel, John Howatt, Dr. R. W. Keeton, C. S. Leopold, André Missenard, Dr. R. R. Sayers, Dr. Charles Sheard, C. Tasker.***

This Committee is a continuing group having the responsibility of presenting at intervals summaries of current physiological researches and their bearing on ventilation practice. A comprehensive report was presented at the 1939 Annual Meeting and it has been the feeling of this Committee that new material bearing on this subject was insufficient to warrant a report this year. It is anticipated that by 1941 a new summary of advances in this field of knowledge will be available for presentation.

Cooperative studies conducted under the auspices of this Committee have been continued at the Medical School of the University of Illinois in Chicago dealing particularly with the important factor of blood volume as related to circulatory changes in the human body. A preliminary report covering these results will be given at the 1941 Annual Meeting and a final report should be available in the spring.

*Member of Committee on Research.

Treatment of Disease, 3

Dr. M. B. Ferderber, *Chairman;* **Dr. C. J. Barone, Dr. A R. Behnke, Dr. B. Z. Cashman, W. L. Fleisher,* Dr. T. L. Hazlett, C. S. Leopold, Dr. C. D. Selby, Dr. A. W. Sherrill, Dr. H. F. Smyth, Dr. C. S. Stephenson, Dr. B. L. Vosburgh.**

The application of air conditioning to operating rooms and recovery wards has been the principal objective of the Committee. One investigation has dealt primarily with the bacteriological content of air introduced to an operating room as the result of cleaning with various types of available equipment. A report covering this work has been released indicating that the average bacterial count in an operating room was decreased with available air cleaning equipment in operation. Cooperative efforts have been initiated with interested groups to study the explosive hazards of combustible gases and vapors commonly used for anesthetic purposes.

Air Conditioning in Industry, 4

W. L. Fleisher,* *Chairman;* **Philip Drinker,* Dr. Leonard Greenburg, H. P. Greenwald, A. M. Kinney, J. W. Kreuttner, L. L. Lewis, H. B. Matzen, Dr. W. J. McConnell, Dr. C. P. McCord, P. A. McKittrick, Dr. R. R. Sayers, Dr. Charles Sheard, C. Tasker,* R. M. Watt, Jr.**

Work conducted at the Research Laboratory this year under the direction of this Committee has dealt primarily with determining differences in physiological reactions of persons in the same atmospheric environment at a low moisture content to check results previously obtained at high relative humidities. A few of the preliminary findings of this study will be reported in a paper presented at the 1941 Annual Meeting and a more comprehensive report of this work will be included in a paper to be prepared for subsequent publication.

Additional observations were made this year to note changes in the leucocyte count. Two other points of investigation are being considered: (1) to obtain data on the relative physiological changes of men and women in exposure to hot environments; and (2) to obtain physiological reactions of persons at different rates of activity to atmospheric environment.

Air Pollution and Purification, 5

C.-E. A. Winslow,* *General Chairman*

Air Pollution: **H. J. Rose,*** *Chairman;* **Philip Drinker,* H. B. Meller, J. S. Owens, Sol Pincus, R. J. Tenkonohy,* E. C. Webb, E. H. Whitlock.**

In accordance with the policy determined at the organization meeting of this Committee in December, 1939, the work of this

group during the past year has been limited principally to a study of the literature relating to sources of outdoor air pollution, methods for controlling such pollution at the source, and a review of urban air pollution surveys. The purpose of this survey is to provide a basis for orientation in planning future work of the Committee.

Removal Atmospheric Impurities: **Dr. Leonard Greenburg,** *Chairman;* **R. S. Dill, Theodore Hatch, L. R. Koller, F. H. Munkelt, G. W. Penney, Dr. E. B. Phelps, F. B. Rowley, C. Tasker,* W. O. Vedder, Jack Waggoner, R. P. Warren, W. F. Wells, Dr. Rene Wiener.**

The work of the Committee is divided into three sub-groups formulated to deal with special aspects of the problem—namely, mechanical, bactericidal and chemical.

The *mechanical* committee has endeavored to obtain factual data for some of the various problems which will have to be dealt with in the future by this Committee. Samples of various types of dust have been collected as they are found in various industrial operations at the point of production, at the effluent from the collector and of the material itself collected by the removal device. These samples have been submitted to careful microscopic particle size determinations and separated into various classifications as follows: (1) under 20 microns, (2) under 10 microns, and (3) under one micron. The findings of this portion of Committee activities have not yet been completely analyzed, but it is planned to extend this work until sufficient data have been obtained to represent a satisfactory picture of the usual type of industrial dust producing processes and dust filtration devices.

The *bactericidal* sub-committee has been active during the past year in the development of literature and the critical examination of experimental data evolved by various members of this group. An extensive report is now being prepared which will be available for publication in January, 1941.

Activity of the *chemical* sub-committee has been limited due to the inability of the personnel to function in view of concentrated work surrounding the defense program of the government.

Contributors to Research

Contributions in support of the research work of the Committee on Research are hereby acknowledged:

Financial Contributions

Aerofin Corp; American Air Filter Co., Inc.; *American Gas Association;* American Marsh Pumps, Inc.; American Radiator & Standard Sanitary Corp.; Anemostat Corporation of America; Barber-Colman Co.; Bell & Gossett Co.; Buffalo Forge Co.; A. M. Byers Co.; Carrier Corp.; Chicago Pump Co.; Crane Co.; Detroit Lubricator Co.; Frick Company, Inc.; G & O Mfg. Co.; Grinnell Co.; *Heating, Piping & Air Conditioning Contractors National Association;* Hoffman Specialty Co.; Illinois Testing Laboratories, Inc.; Independent Register Co.; Ingersoll Steel & Disc: Div. of Borg-Warner Corp.; *Insulation Board Institute;* Johnson Service Co.; Kewanee Boiler Corp.; Kinetic Chemicals, Inc.; Libbey-Owens-Ford Glass Co.; *Metal Window Institute;* Minneapolis-Honeywell Regulator Co.; Narowetz Heating & Ventilating Co.; Nash Engineering Co.; *National Door Manufacturers Assn., Inc.;* National Tube Co.; Owens-Illinois Glass Co.; Pittsburgh Corning Corp.; Pittsburgh Plate Glass Co.; Taylor Instrument Cos.; Waterloo Register Co.; Weil McLain Co.; Westinghouse Electric & Mfg. Co.; York Ice Machinery Corp.

Donors of Equipment or Material

A-V-B Manufacturing Co.; Aluminum Venetian Blind Co.; American Air Filter Co.; American Radiator & Standard Sanitary Corp.; Barber-Colman Co.; Bryant Heater Co.; Carrier Corp.; Chicago Venetian Blind Co.; Crane Co.; Detroit Lubricator Co.; Detroit Steel Products; Ellison Gage Co.; Julien P. Friez & Sons; Hart & Cooley Manufacturing Co.; Ingersoll Steel & Disc: Div. of Borg-Warner Corp.; *Insulation Board Institute;* Johns-Manville; Libbey-Owens-Ford Glass Co.; Minneapolis-Honeywell Regulator Co.; Modine Manufacturing Co.; Mueller Furnace Co.; National Radiator Co.; National Tube Co.; Owens-Corning Fiberglas Corp.; Pittsburgh Plate Glass Co.; P. C. Russell Co.; Trane Co.; Tuttle & Bailey.

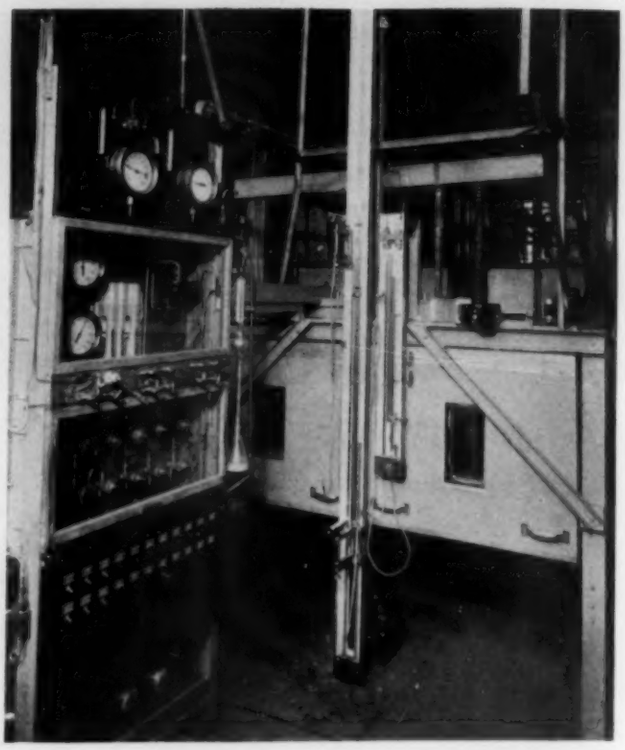

Fig. 1—Apparatus for measuring departures from Dalton's law of air-water vapor mixtures, University of Pennsylvania

Radiation and Comfort, 6

J. C. Fitts, *Chairman;* **A. H. Barker, L. M. K. Boelter, R. E. Daly, E. R. Gurney, L. N. Hunter, A. P. Kratz, C. S. Leopold, D. W. Nelson, W. J. Olvany, G. W. Penney, W. R. Rhoton, C.-E. A. Winslow.***

This Committee was appointed in 1938 to consider all problems relating to radiation as it affects comfort in winter and summer. A comprehensive outline of basic researches was prepared and it was decided to concentrate first on the study to determine the primary sense reactions of relative comfort derived from rooms with normal window arrangements from conducted heat and from heat supplied by both convection and direct radiation.

During the summer of 1939 the necessary building was erected at the ASHVE Research Laboratory in Pittsburgh and throughout the winter of 1939 and 1940 tests were conducted, the results of which will be submitted in a paper to be presented at the Annual Meeting.

It is planned to continue further work on this project at the Research Laboratory during 1941. In addition, the Committee will be responsible for directing a cooperative project at the University of California dealing with radiant heating and cooling.

Instruments, 7

D. W. Nelson, *Chairman;* **F. R. Bichowsky, L. M. K. Boelter, R. S. Dill, M. K. Fahnestock,* A. P. Gagge, J. A. Goff, F. W. Reichelderfer, G. L. Tuve, C. P. Yaglou.**

The development of standards for measuring thermal environment, and more particularly, a uniform appraisal of mean radiant temperature has been the scope of activity for this Committee during the current year. A coordinated investigation of the various factors dealing with thermal environment and physiological reactions is being made at several of the cooperative institutions and the Research Laboratory.

Tentative standards have been approved for blackening globe thermometers and experimental work has been conducted to show the influences of type and location of the instrument for measur-

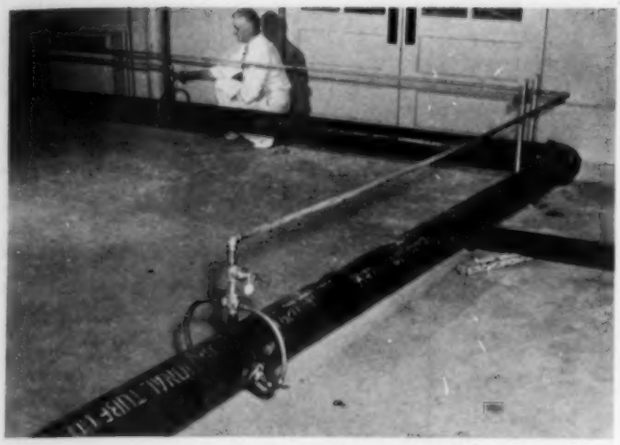

Fig. 2—Determining friction-head in standard pipe, A. & M. College of Texas

ing mean radiant temperature. A low velocity hot wire anemometer for measuring air movement at the location of a globe thermometer has been developed although further analysis and standardization is contemplated.

The problem of uniform air measurement in ducts, at various outlets and inlets and in free spaces is being studied in several laboratories doing cooperative research on air distribution. Out of this experience it is expected that the range and method of application for various instruments will finally be determined. No one instrument can be expected to accurately measure all of the varying conditions encountered in air flow problems.

Weather Design Conditions, 8

T. H. Urdahl,* *Chairman;* **J. C. Albright, P. D. Close, John Everetts, Jr., C. M. Humphreys, J. B. Kincer, O. A. Kinzer, J. W. O'Neill, F. W. Reichelderfer.**

During the past year the Committee's attention and its efforts have been focused upon accomplishing the objectives set forth in its program adopted in 1938. The results of this work of the Committee during 1938 provided valuable additions and corrections to be applied on existing design data, and as reported at that time, established through its work a basis of operation upon which to continue. The objectives as previously reported are repeated herewith as follows:

1. To establish uniform methods of obtaining and analyzing weather data upon which design conditions for any given locality may be based.

2. To quantitatively analyze existing weather data including dry- and wet-bulb temperature, wind velocity, and sunshine, in a manner and over a sufficient period of years to show range and duration by months and seasons following the procedure already employed in obtaining some of the summer data.

3. To supplement the work being done by the U. S. Weather Bureau through obtaining those data which they do not have available. The chief deficiency is wet-bulb data which are only available for approximately four years in most localities. This supplemental work to consist of the taking of wet-bulb and dry-bulb temperatures at a central point in each locality at the street level and at the average roof level for comparison with local temperature differences between business and suburban sections and the influence of solar heat storage in massed pavements, buildings, etc.

4. To make available the information obtained in the foregoing to each locality through assembly, analysis, and distribution from one central point until such time as such work may be done by the Government as a part of its weather reporting program.

5. To recommend to the U. S. Government desired additions to the changes in the data being obtained through the Weather Bureau stations, and to support the required legislative effort as may be necessary to expand the activity of this bureau to include the reporting and dissemination of the data required in order to form a proper and adequate basis for design of heating and air conditioning systems.

Item 1 will be ultimately accomplished upon completion of analytical work under way. The balance of the items are the subject of present cooperative effort with the U. S. Weather Bureau now under the Department of Commerce, whose expanded facilities and appreciation of the Committee's needs are making it possible to obtain basic data which will be of greater accuracy for local application than that upon which engineers have had to depend in the past. Details of this program are enumerated herewith.

A. The U. S. Weather Bureau has available approximately 14,000,000 hourly airway observations of temperature and dew-point which are being analyzed to produce tables of design load data heretofore unavailable. Through correspondence with Committee personnel, representatives of industry and individuals in various departments of the government, six tables of various

Research Papers—1940

Society Laboratory

Seasonal Variation in Reactions to Hot Atmospheres, by F. C. Houghten, A. A. Rosenberg and M. B. Ferderber (February 1940 Journal).

Analysis of the Factors Affecting Duct Friction, by J. B. Schmieler, F. C. Houghten and H. T. Olson (March 1940 JOURNAL).

Heat Gain through Glass Blocks by Solar Radiation and Transmittance, by F. C. Houghten, David Shore, H. T. Olson and Burt Gunst (April 1940 JOURNAL).

Summer Cooling Requirements of 745 Clerks in an Office Building, by Dr. W. J. McConnell and M. Spiegelman (May 1940 JOURNAL).

Summer Cooling Load as Affected by Heat Gain through Dry, Sprinkled and Water Covered Roofs, by F. C. Houghten, H. T. Olson and Carl Gutberlet (July 1940 JOURNAL).

Sensation of Warmth as Affected by the Color of the Environment, by F. C. Houghten, H. T. Olson and John Suciu, Jr. (November 1940 JOURNAL).

Comfort Requirements for Low Humidity Air Conditioning, by F. C. Houghten, H. T. Olson and S. B. Gunst (Annual Meeting, January 1941).

Heat Gain through Western Windows with and without Shading, by F. C. Houghten and David Shore (Annual Meeting, January 1941).

Radiation as a Factor in the Sensation of Warmth, by F. C. Houghten, S. B. Gunst and J. Suciu, Jr. (Annual Meeting, January 1941).

Cooperative Institutions

Effect of Lint on Air Filter Performance, by F. B. Rowley and R. C. Jordan (January 1940 JOURNAL).

The Performance of Stack Heads, by D. W. Nelson (February 1940 JOURNAL).

The Peripheral Type of Circulatory Failure in Experimental Heat Exhaustion—The Role of Posture, by R. W. Keeton, F. K. Hick, Nathaniel Glickman and M. M. Montgomery (February 1940 JOURNAL).

Dynamic and Thermal Behavior of Water Drops in Evaporative Cooling Processes, by H. B. Nottage and L. M. K. Boelter (May 1940 JOURNAL).

Fever Therapy Locally Induced by Conditioned Air, by Dr. M. B. Ferderber, F. C. Houghten and Carl Gutberlet (May 1940 JOURNAL).

Effect of Room Dimensions on the Performance of Direct Radiators and Convectors, by A. P. Kratz, M. K. Fahnestock, E. L. Broderick and S. Sachs (July 1940 JOURNAL).

Air Flow through Supply and Exhaust Openings in Buildings, by G. L. Tuve and D. K. Wright, Jr. (August 1940 JOURNAL).

Development of Instruments for the Study of Air Distribution in Rooms, by A. P. Kratz, A. E. Hershey and R. B. Engdahl (September 1940 JOURNAL).

Summer Cooling in Research Residence with a Gas-Fired Dehydration Cooling Unit, by A. P. Kratz, S. Konzo and E. L. Broderick (December 1940 JOURNAL).

The Influence of Physiological Research on Comfort Requirements, by R. W. Keeton, F. K. Hick, N. Glickman and M. M. Montgomery (Annual Meeting, January 1941).

A Comparison of the Weight, Particle Count and Discoloration Methods of Testing Air Filters, by F. B. Rowley and R. C. Jordan (Annual Meeting, January 1941).

Friction-Heads in Standard Six-Inch Pipe, by F. E. Giesecke and J. S. Hopper (Annual Meeting January 1941).

arrangements of hourly readings of dry-bulb, wet-bulb and dew-point temperature were agreed upon as being of greatest value to the designing engineer. These tables with some slight variations necessary to facilitate compilation will be prepared under the direction of the Weather Bureau in cooperation with a government project located at New Orleans which will employ approximately 200 individuals on the work. In setting up this program, preliminary to the actual compilation, some 29,000 forms are being printed and from 1 to 1½ years will be required to complete the work. These tables will include data for 115 stations throughout the United States and the order in which they will be prepared will likely be based upon the population served by the respective stations.

B. In order to determine local temperature differences mentioned in Item 3 of the basic program, cooperative work is in the process of being initiated in Washington, D. C., through the establishment of several recording stations at representative points taking into consideration geological characteristics of the urban and suburban sections of the city. A comparison of the simultaneous readings obtained with the official Weather Bureau reading for the locality will establish a percentage of variation for sections. The conduct of this work in Washington will enable the development of a procedure which may be applied to other localities in order to obtain these data for each representative city. In this work, the cooperation of local utilities, colleges and universities and especially local Society Chapters is being earnestly sought to provide the personnel required for making the observations.

C. In the recording and abstraction of data for the summary of meteorological data published every 10 years, the Committee has cooperated with the U. S. Weather Bureau along lines of value to the profession and industries concerned with heating, ventilating and air conditioning.

Radiation with Gravity Air Circulation, 9

M. K. Fahnestock,* *Chairman;* R. E. Daly,* R. S. Dill, A. G. Dixon, H. F. Hutzel, J. P. Magos, J. W. McElgin, J. F. McIntire, T. A. Novotney, W. A. Rowe.

Under this Committee, work during 1940 has been a continuation of a program in progress for a number of years as a cooperative project with the University of Illinois. The work may be divided into three parts—*first,* studies for sponsoring and improving methods of testing and rating radiators and convectors, *second,* a study of the effect of the temperature of a cold room upon the heat output of radiators and convectors, and, *third,* study of the effect of steam temperature upon the heat output of convectors. The program for standardization of test was initiated more than a year ago and has been conducted in cooperation with seven interested laboratories and the Bureau of Standards. Three convectors, two with cast-iron heating units and one with a non-ferrous heating unit, and two direct cast-iron radiators are being tested in each laboratory. The results of the tests in each laboratory are to be studied and compared by the staff at the University of Illinois.

Fig. 3—Window shading test house showing outside venetian blind and awning, ASHVE Research Laboratory

In laboratories which are equipped with test rooms surrounded by cold space the temperature of the air in this space is not always uniform. In order to obtain reasonable temperatures in exposed test rooms lower temperatures are maintained in the cold space when large capacity units are tested than when smaller capacity units are tested. To determine if the temperature of the air in the cold space has any appreciable effect upon the heat output, two types of radiators and convectors are being tested in a cold wall experimental room with a varying range of temperatures in the cold space.

Studies to determine the effect of steam temperature upon the heat output of convectors involves testing two types of convectors using varying steam temperatures and inlet air temperatures to ascertain whether there is a difference in the heat output of such units.

Tests will be made in the immediate future to determine whether or not the number of exposed walls in a cold wall test room has any appreciable effect upon the heat output per unit of surface of a direct radiator or per unit of length of convector.

Institutions Cooperating with the Committee on Research

Agricultural & Mechanical College of Texas

Frictional Flow of Water in Pipes
Heating Requirements of Buildings

University of California

Performance of Cooling Towers
Radiant Heating and Cooling

Case School of Applied Science

Air Distribution in Air Conditioned Spaces

Georgia School of Technology

Investigation of Attic Fan Applications

University of Illinois, Engineering

Radiator and Convector Studies
Residence Summer Air Conditioning
Air Distribution Outlets

University of Illinois, Medical School

Human Responses to Physiological Reactions

Lehigh University

Frictional Resistance to the Flow of Air Through Elbows

Michigan College of Mining & Technology

Corrosion in Steam Heating Systems

Michigan State College

Air Flow in Duct Transitions

University of Minnesota

Methods of Rating Air Cleaning Devices

University of Pennsylvania

Measuring Departures from Dalton's Law of Air-Water Vapor Mixtures

Rensselaer Polytechnic Institute

Sound Transmission in Ducts

University of Wisconsin

Effect of Entering Air Temperature and Velocity on Distribution of Air in Enclosed Spaces

Heat Transfer of Finned Tubes with Forced Air Circulation, 10

W. E. Heibel, *Chairman;* William Goodman, H. F. Hutzel, Ferdinand Jehle, S. F. Nicoll, R. H. Norris, L. P. Saunders, R. J. Tenkonohy,* G. L. Tuve, C. F. Wood.

Considerable experimental data collected at Case School of Applied Science through a cooperative agreement with the Soci-

Fig. 4—Test apparatus for determining air filter efficiency, University of Minnesota

ety, dealing with several methods of calculating dehumidifying coils applied to the same design conditions, have been analyzed by the Committee this year. A code for the testing and rating of finned tube coils has been discussed by the Committee personnel with the prospect of making definite recommendations to the code committee of the Society dealing with this subject at an early date.

Cooling Load in Summer Air Conditioning, 11

C. M. Ashley, *Chairman;* **John Everetts, Jr., M. G. Kershaw, A. E. Knapp, C. S. Leopold, L. S. Morse, R. M. Stikeleather, J. H. Walker.***

During the summer of 1939 a cubicle was built at the Research Laboratory for the purpose of studying the effect of sun radiation on heat gain through building walls and roofs. The details of the wall and roof construction are given in the 1939 annual report. During the summer of 1939 many data were accumulated but, unfortunately, some of the wall data were found to be incomplete due to a shift in calibration of the Nicholls' heat flow meters used to determine the rate of heat flow through the walls. A good share of the data on the roof were satisfactory, however, and were reported in a paper read before the 1940 Summer Meeting of the Society.

During the summer of 1940 additional data were obtained on the walls after having aged and recalibrated the Nicholls' heat flow meters. These data will be the subject of a forthcoming paper.

It now appears that the magnitude of sun effect and lag on roofs and walls has been established; also the relative effect of different wall facings. The present cubicle provides information on only three types of wall construction. Two synthetic methods of predicting the results for other wall constructions have been tried; one a purely mathematical method, the other a hydraulic analogy for heat flow. These are only partially satisfactory, since they depend upon the outside surface temperature as a starting point.

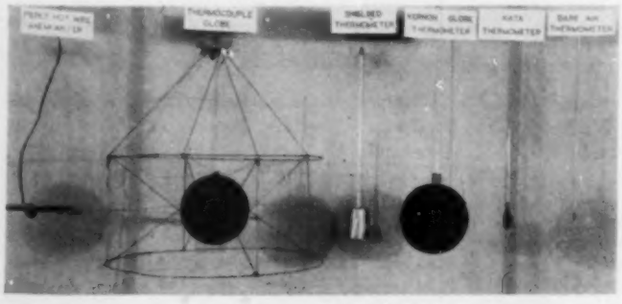

Fig. 5—View of instruments for measuring air environment, ASHVE Research Laboratory

The Committee is also considering the advisability of further experimental work on other wall constructions in order to complete the information on this subject. This would require the construction of another cubicle. Proposals are also under consideration to study the heat storage effect of interior walls due to fluctuation of room temperature, infiltration through swinging and open doors, and heat from appliances.

Solid Fuels, 12

R. A. Sherman, *Chairman;* **C. E. Bronson, W. A. Danielson,* R. S. Dill, H. N. Eavenson, A. C. Fieldner, L. N. Hunter, A. J. Johnson, R. E. Kerr, H. K. Kugel, F. L. Meyer, P. Nicholls, V. F. Parry, H. J. Rose,* L. E. Seeley, C. E. Shaffer, C. Tasker,* E. C. Webb.**

Marked by a thorough discussion of the many problems of the utilization of solid fuels in heating, the one meeting of this committee, held during the Annual Meeting in Cleveland, laid plans for a thorough review of the status and needs for codes relating to solid fuels. Sub-committees charged with the responsibility of reviewing the codes of the boiler industry, the warm air furnace industry, and of the stoker industry have been actively working on their assignments.

Plans have been formulated to develop a fundamental chimney research program with one phase of the work to be done at a cooperative institution and to encourage collection of data on chimneys at other laboratories where research on heating is now being conducted. It is hoped that the information can be coordinated into a useful collection of chimney data.

The project on the combustion of sub-bituminous coals on residential stokers at the Golden, Colorado Station of the U. S. Bureau of Mines is going forward and is being broadened in scope but no publication of results has yet been made.

Summer Air Conditioning for Residences, 13

M. K. Fahnestock,* *Chairman;* **C. F. Boester, E. A. Brandt, John Everetts, Jr., H. F. Hutzel, E. D. Milener, K. W. Miller, F. G. Sedgwick, J. H. Walker.***

All of the active work of this Committee during 1940 was conducted at the warm air heating Research Residence at the University of Illinois. The primary object of the tests conducted in the past summer was to secure operating and performance data on the insulated residence in order to compare these data with similar data obtained with the same residence uninsulated. Dehumidifying equipment was installed with a dry air cooler and resaturation cooler for maintaining indoor conditions from 78 to 80 F dry-bulb and from 45 to 50 per cent relative humidity. These conditions are comparable to those maintained in 1934 when mechanical cooling was used in the uninsulated residence. The primary series of tests was conducted using circulated outdoor air at night when feasible and additional tests were secured keeping the house closed both during the day and night. A paper covering the results of these tests will be presented at the Annual Meeting.

Air Distribution and Air Friction, 14

J. H. Van Alsburg,* *Chairman;* **S. H. Downs, A. E. Hershey, R. D. Madison, L. G. Miller, D. W. Nelson, C. H. Randolph, D. J. Stewart, M. C. Stuart, Ernest Szekely, R. J. Tenkonohy,* G. L. Tuve.**

The work of this Committee has been in progress for a period of four and a half years with investigations being conducted at the Research Laboratory and in five cooperative institutions. Air flow in ducts has been the subject of investigation at the Research Laboratory for a period of four years which has resulted in two papers and a third will be available for presentation at the 1941 Summer Meeting of the Society. All of this work has

dealt primarily with the friction of air in straight ducts. Research on elbows of various radii is being conducted at Lehigh University and a paper covering the first portion of this work will be available for presentation at the next Summer Meeting of the Society. The third project in this field is being investigated at Michigan State College to ascertain the frictional flow characteristics in various types of duct transitions.

In the field of air distribution it was found necessary to first develop a method of testing and correlating instruments on a uniform basis. Some of the first work on the development of instrument standardization was done at Case School of Applied Science which resulted in a paper being presented at the 1940 Fall Meeting of the Society. Additional work at this institution was done this year on the characteristics of supply openings and the air streams delivered into unconfined spaces.

At the University of Wisconsin investigative work has been done to determine the effect of stack heads and approaches on the expansion of an air stream as it leaves a supply opening. This program has resulted in a paper being presented at the 1940 Annual Meeting and another report is now in preparation for publication at an early date.

Another project on air distribution involves the effect of inlet and exhaust opening location on the motion and distribution of air within a room which is being conducted at the University of Illinois. The primary objective of this program is to determine the location of air inlet and outlet to a room which will give the most uniform temperature throughout a room and still provide no objectionable air motion. A preliminary paper covering this work was presented at the 1940 Fall Meeting and it is expected that additional papers covering this work will be available for presentation in the near future.

Heat Requirements of Buildings, 15

P. D. Close, *Chairman;* **E. K. Campbell, J. F. S. Collins, Jr., E. F. Dawson, W. H. Driscoll, H. M. Hart, E. C. Lloyd, H. H. Mather, C. H. Pesterfield, F. B. Rowley, R. K. Thulman, J. H. Walker.***

Through the support of earmarked funds a cubicle 15 x 15 x 8 ft high was built on the premises of the Bureau of Mines in Pittsburgh and located in the ground to simulate an actual basement. It is expected that such a structure will have the advantage of eliminating interference from occupants and will permit the maintenance of constant conditions. Thermocouples have been placed at various locations which will be recorded by the staff at the Research Laboratory. Insulation has been placed on the outside of two walls of the cubicle and although no insulation has been placed in the floor it is expected that this can be added later for future tests. The structure has an insulated ceiling and is electrically heated with the temperature thermostatically controlled. The testing program is planned to study the heat flow characteristics through basement walls, ground temperatures, heat loss coefficients and possible summer condensation.

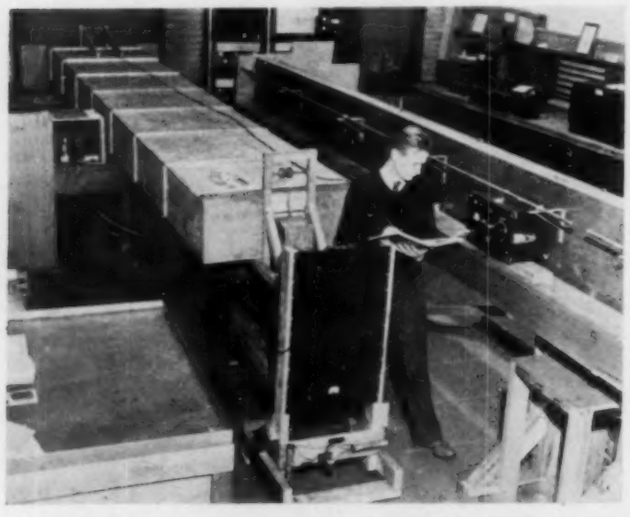

Fig. 6—Measuring noise transmission in an air duct, Rensselaer Polytechnic Institute

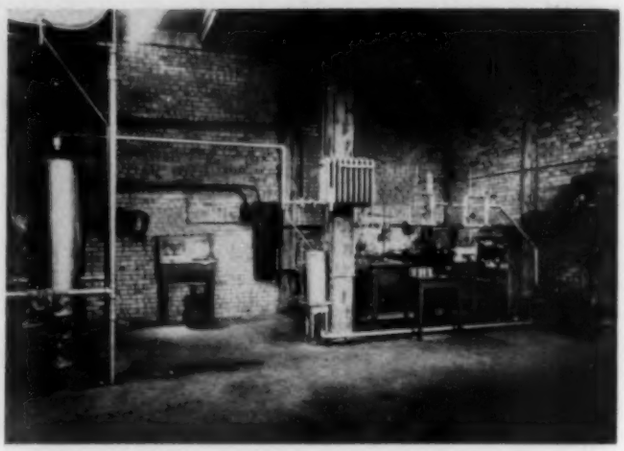

Fig. 7—Apparatus for measuring corrosion in steam heating system, Michigan College of Mining and Technology

In addition the Committee has under consideration a proposal for the study of heat transmission through wet wall conditions and a mathematical study of the heating load for intermittently heated buildings.

Air Conditioning Requirements of Glass, 16

M. L. Carr, *Chairman;* **C. M. Ashley, L. T. Avery, F. L. Bishop, W. A. Danielson,* H. C. Dickinson, J. D. Edwards, J. E. Frazier, S. O. Hall, E. H. Hobbie, C. L. Kribs, Jr., Axel Marin,* R. A. Miller, F. W. Parkinson, J. H. Plummer, W. C. Randall, L. T. Sherwood, J. T. Staples, G. B. Watkins, F. C. Weinert.**

Two meetings of this Committee were held during the current year and plans were formulated for initiating a comprehensive investigation at the Research Laboratory on the value of sun arresting appurtenances. This program was planned to yield information most urgently needed and to constitute a general survey of the subject. A paper covering tests which could be completed in the limited time available will be presented at the Annual Meeting.

The solar heat gain measurements were made with the turntable-mounted twin-cubicles built for use in a previous study of solar heat gain through glass blocks. In general, each test consisted of measuring the simultaneous heat gain through two different kinds of window shading. Devices tested included an awning, an outside venetian blind, an inside venetian blind, an outside shading screen, a shading screen outside and a venetian blind inside and a half-drawn roller shade. In addition, simultaneous tests were made upon single glazed and double glazed glass, heat absorbing glass and upon wood and steel sash.

Insulation, 17

R. T. Miller, *Chairman;* **E. A. Allcut, R. E. Backstrom, Wharton Clay, R. E. Daly,* W. A. Danielson,* H. C. Dickinson, J. D. Edwards, W. V. Hukill, E. C. Lloyd, Paul McDermott, E. W. McMullen, W. T. Miller, E. R. Queer, F. B. Rowley, W. S. Steele, J. H. Waggoner, G. B. Wilkes.**

The principal activities of this Committee during the year 1940 dealt with the review of a memorandum on insulation for submittal to the Guide Publication Committee covering reflective materials. Consideration has been given to the preparation of a coordinated program of fundamental research which would have value to the entire industry. As a new code for testing insulat-

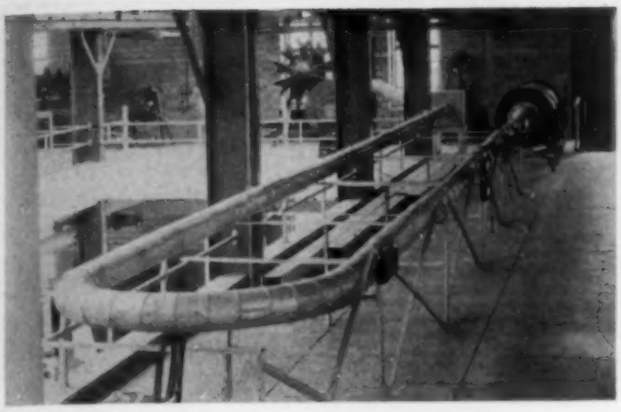

Fig. 8—Equipment for determining elbow friction loss in air duct, Lehigh University

ing materials is now completed it is hoped that a program may be developed for retesting all insulating and building materials on a uniform basis for future inclusion in the GUIDE tables.

Sound Control, 18

J. S. Parkinson, *Chairman;* **E. L. Anderson, C. M. Ashley, A. L. Kimball, V. O. Knudsen, R. D. Madison, R. F. Norris, C. H. Randolph, A. E. Stacey, Jr.,* G. T. Stanton, A. G. Sutcliffe, R. M. Watt, Jr.**

Research work on the nature of noise in duct systems was initiated this year through a cooperative agreement with Rensselaer Polytechnic Institute. The Committee prepared an outline of the work to be done and cooperated in selection of equipment and test procedures. At the present time the work is under way, although no formal report has yet been issued.

A meeting of the Committee was held in Washington in June of this year where a revision of the table of acceptable noise levels which appears in the GUIDE was prepared. This revision is based on more recent surveys of typical noise levels which have been published within the last two years. Methods of rating apparatus noise were discussed and an agreement was reached in principle as to the most desirable procedure. Several members of the Committee undertook to investigate further certain aspects of this problem.

Cooling Towers, Evaporative Condensers and Spray Ponds, 19

B. M. Woods,* *Chairman;* **J. C. Albright, W. W. Cockins, S. C. Coey, E. H. Hyde, E. H. Kendall, S. R. Lewis, J. Lichtenstein, H. B. Nottage, J. F. Park, E. T. Selig, Jr., E. H. Taze.**

The work on cooling towers and spray ponds has progressed along several lines since the previous report of this Committee. A complete set of tests has been conducted under a cooperative agreement with the University of California on a spray pond and the results are being evaluated for publication at an early date. Also partial evaluation of the test results obtained on the atmospheric tower has been accomplished. Further tentative computations on the cooling of falling drops have been completed. A study of experimental results on cooling ponds available has been initiated. A summary of the latest techniques of cooling tower packing which involved a comparison of the behavior of approximately 10 different types of European and American towers has been prepared under the direction of the Committee for use in the 1941 edition of the GUIDE. Developed during the past summer has been a technique for the testing of single elements of cooling tower packing. A hot wire anemometer which will record fluctuating flow and a fog-measuring device have been completed during the past year. An accurate dew-point recorder and a pressure plate type of fluctuating air flow measuring instrument have been designed. An outline of work for tests on an evaporative condenser has been formulated which will begin as soon as the necessary equipment has been obtained to initiate the project.

Psychrometry, 20

F. R. Bichowsky, *Chairman;* **D. B. Brooks, W. H. Carrier, H. C. Dickinson, A. W. Gauger, J. A. Goff, William Goodman, A. M. Greene, Jr., L. P. Harrison, F. G. Keyes, A. P. Kratz, D. M. Little, Axel Marin,* D. W. Nelson, W. M. Sawdon, F. O. Urban.**

The major activity of this Committee is an exact determination of the thermodynamic properties of air-water vapor mixtures. Through a cooperative agreement with the University of Pennsylvania suitable apparatus has been designed and built for measuring the departures from Dalton's Law of air-water vapor mixtures. The apparatus is operating successfully at the present time and preliminary results have been obtained. These data are now being extended, checked and analyzed.

Corrosion, 21

A. R. Mumford, *Chairman;* **H. E. Adams, J. F. Barkley, L. F. Collins, W. H. Driscoll, T. J. Finnegan, W. Z. Friend, R. R. Seeber, E. T. Selig, Jr., F. N. Speller, J. H. Walker.***

The cooperative work at Michigan College of Mining and Technology, which was interrupted during 1939 by a destructive fire, has been resumed in a new laboratory. This work is expected to furnish information on the quantities of non-condensible gases which are dissolved in the condensate formed in a heating system operated at several different rates of condensation. Some studies have been made of the operation of storage type water heaters by means of steam controlled at the condensate outlet rather than at the steam inlet. This type of control offers possibilities in the reduction of corrosion resulting from non-condensible gases. A report of a test of the corrosiveness of various materials of construction of air conditioning equipment was discussed at a committee meeting in Washington in June of this year. It has been planned to present this report in a more extensive form in a subsequent publication, possibly with the inclusion of additional experimental data.

Flow of Fluids Through Pipes and Fittings, 22

S. R. Lewis, *Chairman;* **L. A. Cherry, G. C. Davis, T. M. Dugan, Earle W. Gray, R. T. Kern, H. A. Lockhart, Axel Marin,* R. F. Taylor, E. L. Weber.**

The activities of this Committee have been confined to a cooperative research project being investigated at the Agricultural and Mechanical College of Texas. The Committee collected a special fund to cover the cost of erecting a large section of 6-in. pipe, with valves, fittings, and sections of both welded and screwed methods of assembly.

This test was made because of the rapidly increasing use of large size piping in forced circulation hot water heating. Very little is known as to the effect of turbulence following obstructions such as by tees, and following changes in direction as at elbows, and whether the same relative frictional value due to any specific resistance in a small pipe conveying a liquid applies to a large pipe.

The influence of incrustation which may occur over a period of years on the inside of piping used for carrying recirculated hot water has had little authoritative study. The effect on ultimate resistance to flow of the oxidation which may occur when a water pipe alternately is wetted and dried also needs elucidation, since there are very wide variations in allowances by different authorities.

The tests for friction in 6-in. piping have been completed and will be presented at the Annual Meeting. They indicate that minor corrections not of serious consequence will be required in the GUIDE tables. The tests on effect of long time use under service conditions are now under investigation.

GOLDEN GATE BECKONS

The Semi-Annual Meeting 1941 will be the first meeting of the Society on the Pacific Coast, and it will be held in San Francisco during the week of June 16. Headquarters will be at the Palace Hotel conveniently located in the downtown business district easily accessible to the Civic Auditorium where the Pacific Heating and Air Conditioning Exposition will be held.

It is the belief of Pres. F. E. Giesecke that the meeting and Exposition will attract a large attendance of interested engineers and others who wish to exchange ideas and study the engineering phases of heating, ventilating and air conditioning. The meeting of the engineering and contractor groups together with the Exposition should provide a great stimulus to the progress of air conditioning by promoting industrial production through increase of human efficiency and provide healthful benefits for those concerned with living comfort, in the opinion of W. L. Fleisher, First Vice-President of the Society and Chairman of the Advisory Exposition Committee.

N. H. Peterson, President of the Golden Gate Chapter, says that every chapter member is looking forward with great interest to the Society's meeting and the Exposition in June and extends a cordial invitation to every Society member to visit the Pacific Coast. The Golden Gate Chapter has announced its Arrangements Committee with the following personnel: G. M. Simonson, *General Chairman;* Clyde Bentley, *Vice-Chairman;* Dr. B. M. Woods, *Vice-Chairman;* J. H. Hill, *Reception;* R. A. Folsom, *Transportation;* C L. Peterson, *Entertainment;* N. H. Peterson, *Banquet;* J. F. Kooistra, *Ladies;* E. W. Simons, *Publicity;* A. J. Bouey, *Finance;* and F. W. Kolb, *Sports.*

The 52nd Annual Meeting of the *Heating, Piping and Air Conditioning Contractors National Association* is announced by Pres. J. E. McNevin, for the week of June 16 at the St Francis Hotel, San Francisco, and he reports great enthusiasm for the events, which will focus attention on the entire heating, ventilating and air conditioning profession and industry when it gathers in San Francisco next June.

COLLEGES TO TRAIN ENGINEERS FOR DEFENSE JOBS

Special courses at Government expense for the intensive training of over 30,000 students with technical backgrounds to meet future needs of both industry and Government in carrying out the defense program will shortly be established at qualified engineering schools of college grade. Funds to finance this program were voted by Congress in the recent supplementary Defense Appropriation Act, which provides $9,000,000 to be expended for this purpose under the direction of John W. Studebaker, U. S. Commissioner of Education. Allotments will be made to the cooperating institutions to meet expenses incurred in giving instruction under the plan.

Courses of study will be given by the colleges both for those able to devote their entire time to preparation for future defense jobs and for workers now employed who desire to fit themselves for more responsible assignments. All instruction will be of college grade equivalent to that given regular candidates for a degree, but the special courses, which will require from two to eight months of study, will concentrate upon training of immediate practical application to specific defense jobs. Classes will be held both at the engineering schools and in or near industrial plants for the benefit of part-time and evening students. The regular college teaching staffs will be supplemented by additional teachers, including specially qualified men from the industries to be served.

Participation in the program is limited to institutions offering regular engineering curricula leading to a degree and which operate under charters exempting them from taxation. About 150 engineering schools in state universities, land-grant colleges, and private colleges and universities are eligible.

Federal allotments to the participating colleges may be used to meet the cost of salaries, materials and supplies, reference books, the operation of buildings, the maintenance and repair of equipment and, to a limited extent, the purchase or rental of additional equipment and the leasing of space in non-college buildings. No expenditures are authorized for the purchase or construction of buildings, nor is provision made to defray the living expenses of students. Students will pay no tuition charges.

The training program is the outgrowth of several months of preliminary investigation into needs for technically trained personnel by the U. S. Office of Education. During the past summer a preliminary survey of the situation was made by Andrey A. Potter, dean of the School of Engineering of Purdue University, working with Federal agencies and with industries in the defense program. This is now being supplemented by sample investigations in specific areas, including New York City, Philadelphia, Pittsburgh, Chicago, and San Francisco, under the direction of Dean Potter, H. P. Hammond, dean of engineering, Pennsylvania State College; Thorndike Saville, dean of engineering, New York University, and Prof. B. M. Woods, Department of Mechanical Engineering, University of California. The data so obtained will guide in determining the first courses to be given and the methods to be used in determining further needs.

Further to determine training needs as they develop, the Office of Education has just completed arrangements under which selected colleges and universities have made available 22 regional advisers who will serve without compensation.

Dean E. L. Moreland, Massachusetts Institute of Technology, Cambridge, Mass. (Maine, Massachusetts, New Hampshire, and Vermont).

Prof. L. E. Seeley, Yale University, New Haven, Conn. (Connecticut and Rhode Island.)

Dean S. C. Hollister, Cornell Univer-

sity, Ithaca, N. Y. (New York State, except New York City).

Dean J. W. Barker, Columbia University, New York, N. Y. (New York City and Long Island).

President A. R. Cullimore, Newark College of Engineering, Newark, N. J. (northern New Jersey).

W. T. Spivey, Drexel Institute of Technology, Philadelphia, Pa. (eastern Pennsylvania, southern New Jersey and Delaware).

Dean S. S. Steinberg, University of Maryland, College Park, Md. (District of Columbia and eastern Maryland).

Dean Blake R. Van Leer, North Carolina State College, Raleigh, N. C. (North Carolina, South Carolina, and Virginia).

Prof. J. E. McDaniel, Georgia School of Technology, Atlanta, Ga. (Alabama, Florida, Georgia, Mississippi, and eastern Tennessee).

Dean F. L. Wilkinson, Jr., University of Louisville, Louisville, Ky. (Kentucky, southern Ohio, and southwestern half of West Virginia).

J. D. Beatty, Carnegie Institute of Technology, Pittsburgh, Pa. (western half of Pennsylvania, northeastern half of West Virginia, and western Maryland).

Dean C. E. MacQuigg, Ohio State University, Columbus, Ohio (northern half of Ohio).

Dean H. B. Dirks, Michigan State College, Lansing, Mich. (southern Michigan).

President D. B. Prentice, Rose Polytechnic Institute, Terre Haute, Ind. (Indiana, except for Chicago industrial area).

President H. T. Heald, Illinois Institute of Technology, Chicago, Ill. (Illinois, southern Wisconsin, and the Chicago industrial area in Indiana).

Prof. H. O. Croft, University of Iowa, Iowa City, Iowa (Iowa, Minnesota, Nebraska, North Dakota, South Dakota, northern Wisconsin, and northern Michigan).

Dean A. S. Langsdorf, Washington University, St. Louis, Mo. (Arkansas, Kansas, Missouri, Oklahoma, western Tennessee).

Dean W. R. Woolrich, University of Texas, Austin, Tex. (Louisiana and Texas, east of Pecos River).

President M. F. Coolbaugh, Colorado School of Mines, Golden, Colo. (Colorado and Wyoming).

Prof. R. L. Daugherty, California Institute of Technology, Pasadena, Calif. (Arizona, New Mexico, southern California and Texas, west of Pecos River).

Dean S. B. Morris, Stanford University, Stanford University, Calif. (northern California, Nevada and Utah).

Prof. H. H. Langdon, State College of Washington, Pullman, Wash. (Idaho, Montana, Oregon and Washington).

L. E. Seeley
President

W. K. Simpson
Vice-President

E. J. Rodee
Secretary-Treasurer

CONNECTICUT HOLDS INAUGURAL BANQUET AND FIRST MEETING

November 8, 1940. The inaugural banquet and first meeting of the Connecticut Chapter of the Society was held at the New Haven Lawn Club, New Haven, with 105 members and guests in attendance.

F. E. Giesecke, College Station, Tex., President of the Society, presented the Chapter with the Charter and installed the following as officers to serve for the coming year:

President—L. E. Seeley.
Vice-President—W. K. Simpson.
Secretary-Treasurer—E. J. Rodee.
Board of Governors—C. G. Chapin, Stanley Hart, C. J. Lyons and J. R. Smak.

Dr. C.-E. A. Winslow, toastmaster for the evening, introduced representatives of various Connecticut professional organizations, who welcomed the Connecticut Chapter as a new group to cooperate with these organizations. Among those introduced were: R. G. Warner, chairman, Connecticut Technical Council; C. F. Scott, chairman, State Board of Registration for Professional Engineers and Land Surveyors; E. V. Meeks, president, Architects' Examining Board of the State of Connecticut, and S. W. Dudley, dean of School of Engineering, Yale University.

The final speaker of the evening was W. H. Carrier, Syracuse, N. Y., past president of the Society, who addressed the gathering on the topic "The Heating and Ventilating Engineer." In his speech, Mr. Carrier brought forth one idea which was exceptionally well taken, and that was, the heating and ventilating engineer should be regarded as a *thermal engineer*.

Besides the speakers of the evening, there were many other distinguished guests who brought greetings from the Society and various Chapters. Among these were, W. L. Fleisher, New York, First Vice-President, M. F. Blankin, Philadelphia, Treasurer, A. J. Offner, New York, chairman of the Finance Committee, T. H. Urdahl, Washington, D. C., member of the Council, W. T. Jones, Boston, Past President, R. H. Carpenter, New York, former member of the Council, F. C. Houghten, Pittsburgh, Director, ASHVE Research Laboratory, Prof. M. K. Fahnestock, Urbana, University of Illinois and representing Illinois Chapter, C. M. F. Peterson, Cambridge, secretary of Massachusetts Chapter, John James, New York, Technical Secretary, and A. V. Hutchinson, New York, Secretary.

Congratulatory telegrams and letters were received from the following Chapters: Golden Gate, Michigan, Northern Ohio, Oregon, North Carolina, Pittsburgh, North Texas, Minnesota, Atlanta, Delta, and from Prof. A. P. Kratz, Urbana, N. D. Adams, Rochester, Minn., E. K. Campbell, Kansas City, all members of the Council, and also from Homer Addams, New York, and D. S. Boyden, Shirley, Mass., both past president of the ASHVE.

ENGINEERING EXAMINERS ANNOUNCE MEETING

The 22nd Annual Meeting of the National Council of State Boards of Engineering Examiners will be held in New York City in October, 1941, according to the announcement of Pres. V. M. Palmer. The present membership of the Council consists of 43 legally constituted Boards of Registration for Professional Engineers, which have a total appointed membership of 233. These member boards represent approximately 68,000 engineers.

Air view of downtown district

A S H V E IN KANSAS CITY

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January 27-29

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ALL plans have been completed for the Society's 47th Annual Meeting, January 27-29, 1941, at Hotel Muehlebach, Kansas City, Mo., according to the announcement of John M. Arthur, Jr., General Chairman of the Committee on Arrangements.

A well balanced program of business and entertainment has been prepared. The morning of January 27 will be devoted to a series of committee meetings and a conference of chapter delegates. The official representatives of 31 chapters will be present to discuss problems of mutual interest.

A get-together luncheon will be held at noon on Monday, and the First Technical Session will be called to order by Pres. F. E. Giesecke at 2:00 p.m. During the meeting 13 technical papers will be presented, of which 3 come from the Society's Research Laboratory, and 4 are offered by cooperating institutions where research is sponsored by the Society.

The reports of the officers and various committees will be submitted for consideration and discussion. The report of the Committee on Research, printed on page 64 of this issue, reveals the extent of the work carried on during 1940, and indicates the importance of these varied activities which are carried on by the Society.

The Guide Publication Committee will outline its work during the past year which has resulted in the production of the 19th edition of THE GUIDE.

There will be a meeting of the Nominating committee to discuss candidates for office and the Council will meet in advance of the sessions to dispose of old business and at the conclusion of the meeting the new Council will organize.

Many serious questions will be debated at the sessions, some of which involve fundamental matters of policy.

However, there will be some time available for diversion and there will be an opportunity to gather for a Social Hour at 6:00 p.m. on Monday evening following which there will be an informal dinner party. The visiting ladies will be entertained during the day at a card party, and a sightseeing trip of Kansas City has been arranged.

The big social event of the meeting will be the banquet and dance on Tuesday, at which W. A. Russell will be toastmaster, and Tom Collins will be the speaker.

E. M. Jolley

The officers and members of Kansas City Chapter are waiting to welcome their fellow members and want them to enjoy every minute of their stay in the "Heart of America."

Henry Nottberg, Jr.

Method of Choosing Location of, Financing and Conducting Meetings of the Society

Resolved: That inasmuch as the Annual and Semi-Annual Meetings of the Society come under the jurisdiction of the Council, the following rules governing the handling of such meetings be adopted by the Council and published in the JOURNAL of the Society at least twice during every year, preferably just prior to each meeting.

1—The Council will select the city in which the Annual or Semi-Annual Meeting is to be held, giving due consideration to the invitations received from Chapters or members as well as to the advisability of so distributing those meetings as to make them of the greatest advantage to the general membership, and to reduce as far as possible the expense of members attending.

2—That an appropriation be made to cover the entertainment or local expenses, incurred in connection with the meeting not exceeding $500.00, the regular meeting expense to be taken care of by the General Fund of the Society in the regular way.

3—That no registration fee or compulsory obligations of any nature be imposed on members or guests.

4—That the purchase of tickets for banquets or for any other form of entertainment that may be provided be entirely voluntary.

5—That the grouping of features and the sale of tickets for group features be discouraged.

6—That the raising of funds from manufacturers of heating apparatus be discouraged.

7—That the display of samples, or of literature, advertising the product of any manufacturer in any way, shape or form, be not permitted at the booths, registration desk, or in or about the meetings.

8—That the distribution of trade papers be entirely at the discretion of the committee in charge.

9—That the local Chapter or local members be empowered to form a General Committee with such sub-committees as may be required to handle the details of transportation, hotel accommodations, entertainment, finance, etc., and that this General Committee be requested to confer frequently with the Council, through the Secretary of the Society, and to make frequent reports on progress in connection with the various matters being handled by them.

10—That the arrangements of elaborate and costly entertainment features be discouraged.

Adopted at Council Meeting, January 29, 1926.

47th Annual Meeting Program

HOTEL MUEHLEBACH ASHVE KANSAS CITY, MO.

John M. Arthur
General Chairman

W. L. Cassell
Co-Chairman

A. D. Marston
Vice-Chairman

N. W. Downes

Sunday, January 26

1:30 p.m. Reception of Members and Ladies (Music Room—Mezzanine)
2:30 p.m. Council Meeting (Room No. 1—Mezzanine)
6:30 p.m. Social Hour and Buffet Supper (Kansas City Club)
8:30 p.m. Meeting Committee on Research (Room No. 1—Mezzanine)

Monday, January 27

8:30 a.m. Registration (Mezzanine Floor)
9:00 a.m. Committee Meetings
9:30 a.m. Chapter Delegates Conference (Junior Ballroom)
12:30 p.m. Joint Luncheon with K. C. Engineers Club—*Speaker*, Dr. F. E. Giesecke; *Subject*, Factors Affecting the Span of Human Life
2:00 p.m. TECHNICAL SESSION (Ballroom—Mezzanine)
Reports of Officers and Council Committees
A Comparison of the Weight, Particle Count and Discoloration Methods of Testing Air Filters, by Frank B. Rowley and Richard C. Jordan
Comfort in High Altitude Flying, by D. W. Tomlinson
Boiler Testing Codes, by J. F. McIntire
Warm Air Furnace Testing Codes, by F. L. Meyer
Codes in the Stoker Industry, by E. C. Webb
Report of Tellers of Election.
6:00 p.m. Social Hour (Music Room)
7:00 p.m. Informal Get-together Dinner and Entertainment
9:00 p.m. Organization Meeting 1941 Committee on Research (Room No. 1—Mezzanine)

Tuesday, January 28

8:30 a.m. Meeting of Nominating Committee (Music Room)
10:00 a.m. TECHNICAL SESSION (Ballroom—Mezzanine)
Report of Committee on Research—A. E. Stacey, Jr., Chairman
Friction-Heads in Standard Six-Inch Pipe, by F. E. Giesecke and J. S. Hopper
Radiation as a Factor in the Sensation of Warmth, by F. C. Houghten, S. B. Gunst and J. Suciu, Jr.
Operating Costs of Residence Wall Heating System, by E. J. Rodee
12:15 p.m. Get-together Luncheon
2:00 p.m. TECHNICAL SESSION (Ballroom—Mezzanine)
Comfort Requirements for Low Humidity Air Conditioning, by F. C. Houghten, H. T. Olson and S. B. Gunst
The Influence of Physiological Research on Comfort Requirements, by R. W. Keeton, F. K. Hick, Nathaniel Glickman and M. M. Montgomery
Comfort and Health and Temperature—A Mathematical Solution, by W. L. Fleisher and W. L. Fleisher, Jr.
Summer Cooling in Research Residence with a Gas-Fired Dehydration Cooling Unit, by A. P. Kratz, S. Konzo and E. L. Broderick
7:00 p.m. Banquet and Dance (Ballroom). Toastmaster, W. A. Russell; Speaker, Tom Collins.

Wednesday, January 29

10:00 a.m. TECHNICAL SESSION (Trianon Room)
A Laboratory Method for Cyclic Heat Measurements on Walls and Roofs, by F. G. Hechler and E. R. Queer
Reheating by Means of Refrigerant Compressor Discharge Gas, by S. F. Nicoll
Heat Gain Through Western Windows With and Without Shading, by F. C. Houghten and David Shore
1:30 p.m. Council Meeting (Room No. 1—Mezzanine)

Mrs. W. A. Russell

Roger Campbell

F. F. Dodds

L. A. Stephenson

IOWA MEETINGS

December 10, 1940. The December meeting of the Iowa Chapter of the Society was held at the Hotel Russell Lamson, Waterloo, and was attended by 30 members and guests. Pres. R. A. Norman called the meeting to order and the first business transacted was the selection of a representative and an alternate to attend the 47th Annual Meeting of the Society in Kansas City, January 27-29, 1941. President Norman was selected as delegate and M. L. Todd as alternate. All the members were urged to attend this meeting.

A. L. Walters then moved that the delegate and alternate be named as the official representative and alternate to serve on the Nominating Committee of the Society; the motion was seconded and the vote was unanimous. President Norman then instructed the Secretary to certify the names of the official representatives to the Secretary of the Society as required by the By-Laws.

Perry LaRue then pointed out that the next Chapter meeting was to be held in Des Moines on January 14, 1941, and the speaker would be S. Frank Cox, Pittsburgh, who will speak on insulated windows. Mr. LaRue suggested that a special invitation be sent to all architects to attend this meeting.

Mr. LaRue said that the February meeting was scheduled for Des Moines and that an effort would be made to obtain one of the Society Officers to address the meeting. The March meeting is planned for Iowa City and the April meeting in Ames.

W. G. Frank, chief engineer, Dust Control Div., American Air Filter Co., then presented a discussion on dust control with particular reference to the interest of the heating and ventilating engineer in the problem of dust control. Mr. Frank presented the elementary problems of dust control together with their solutions and then discussed particularly the possibilities of reintroducing exhausted air after cleaning as a possible solution to the problem of heating and cooling make-up air. Following Mr. Frank's presentation a number of questions were asked by the members and the meeting was concluded.

November 12, 1940. A very interesting dinner meeting was held at the Kirkwood Hotel, Des Moines, attended by 22 members and guests. Pres. R. A. Norman called the meeting to order following which the minutes of the October meeting were read and approved.

It was unanimously agreed that action on the new By-Laws would be postponed until the December meeting, at which time it was planned that they would be taken up, discussed and disposed of.

Perry LaRue, chairman of the meetings committee, reported on his plans. Arrangements for the January meeting were confirmed, and the secretary was instructed to invite all architects in the territory.

President Norman pointed out that the Ames program would be somewhat different this year in that it would be held on Tuesday and Wednesday only, and that the ASHVE meeting would be held on Tuesday evening. He also mentioned that it was hoped to have Prof. M. K. Fahnestock, University of Illinois, address this meeting.

Following several announcements President Norman displayed the new Iowa Chapter Charter, which was turned over to the secretary for safe keeping.

M. L. Todd then presented an informal talk on the subject of air distribution. He pointed out some of the fundamentals established as a result of a large amount of his own research and illustrated his points with many charts. Various members lead discussions on different phases of this problem and many of those present contributed their comments. It was late in the evening when the meeting was finally adjourned by President Norman with the feeling that if he did not take formal action, it would have gone on indefinitely. It was decided that this type of meeting was very interesting and helpful and that the chapter should have more of them.

MOTORS AND CONTROLS DISCUSSED AT ONTARIO

December 2, 1940. The December meeting of the Ontario Chapter was held at the Royal York Hotel, with 47 members and guests in attendance. Following dinner, Pres. J. W. O'Neill announced the resignation of F. E. Ellis from the Board of Governors, and E. R. Gauley was appointed to fill this vacancy.

President O'Neill then announced that H. R. Roth would be the Chapter delegate to the 47th Annual Meeting in Kansas City, and C. Tasker would be alternate. Mr. Tasker was appointed to the Nominating Committee and Mr. Roth as alternate. The president also announced that it was hoped that the Council meeting in April would be in Toronto, at which time the Toronto Chapter would extend invitations to the Winnipeg and Montreal Chapters for a Canadian group meeting.

H. M. Treleaven, chairman of the ask-it-basket committee, then read a number of questions which had been sent in, together with the answers.

President O'Neill announced that the Society still had a number of codes covering steam and hot water heating of residences for sale.

The principal speaker of the evening, Rae McGeoch, was introduced by the president, and addressed the meeting on the subject of motors and controls for air conditioning equipment. His talk was accompanied by various slides which were extremely interesting. Following his address there were many questions asked which brought on a general discussion of motor problems in the industry. A rising vote of thanks was extended the speaker, followed by adjournment.

PRESIDENT GIESECKE VISITS PITTSBURGH

November 18, 1940. Pres. F. C. McIntosh called the November meeting of the Pittsburgh Chapter to order in the blue room of the Hotel Roosevelt, with 107 members and guests in attendance. Because of the lengthy program planned, all regular business was dispensed with except the report of the nominating committee, which proposed the following candidates: *President*—E. C. Smyers; *Vice-President* — C. M. Humphreys; *Secretary*—T. F. Rockwell; *Treasurer*—L. S. Maehling; *Board of Governors*—F. C. McIntosh, G. G. Waters and H. B. Steggall.

F. E. Giesecke, president of the Society, and professor emeritus at the Texas A. & M. College, College Station, Tex., gave an interesting talk on radiant heating and cooling, which he presented in an able and comprehensive manner. He started

with fundamentals of radiant heat transfer, then discussed factors which govern the design of radiant heating, and concluded by showing slides of installations, both in this country and abroad. This subject brought about considerable discussion from the floor, which continued long after Dr. Giesecke finished his presentation.

In honor of Dr. Giesecke's visit, W. N. Jones, director of the College of Engineering, Carnegie Institute of Technology, and E. A. Holbrook, dean of School of Engineering, University of Pittsburgh, were guests of the chapter, and each spoke briefly.

The meeting adjourned at 10:25 with a rising vote of thanks to Dr. Giesecke.

PHILADELPHIA HOST TO PRESIDENT GIESECKE

November 14, 1940. The Philadelphia Chapter held its regular monthly meeting at the Engineers Club of Philadelphia. Pres. C. B. Eastman called the meeting to order and the October minutes were read and approved. This was followed by the report of the treasurer, which was accepted as read.

President Eastman called attention to the fact that plans were being made and were well under way for the Society's 48th Annual Meeting, which is scheduled for January, 1942, in Philadelphia.

Following the announcement that T. A. Novotney, Johnstown, Pa., would address the December meeting, Merrill F. Blankin introduced the guest of honor, Dr. F. E. Giesecke, President of the Society, who was given a very hearty welcome. President Giesecke spoke on the subject of radiant heating and cooling, which was of great interest, as numerous questions were raised and considerable discussion followed. On motion of A. J. Nesbitt, a rising vote of thanks was extended to Dr. Giesecke, and the meeting adjourned at 9:40 p.m.

ATLANTA HOLDS MEETING

November 12, 1940. The regular monthly meeting of the Atlanta Chapter was held at the Biltmore Hotel, with Pres. T. T. Tucker presiding and an attendance of 80 members and guests.

H. King McCain, chairman of the research committee, announced that due to his work requiring him to be out of town for several months, he would not be able to continue as chairman of this committee and Mr. Tucker was appointed to take over that duty.

An announcement of the 47th Annual Meeting of the Society in Kansas City in January was then made by the president.

A motion was made to suspend regular routine business in order to give more time to the speaker, Sidney R. Orem, Jr., who was then introduced. Mr. Orem gave an interesting presentation on the electrostatic air cleaner and demonstrated the Precipitron.

C. B. Cole, a member of the nominating committee, reported the following as nominees for officers for the coming year: *President*—S. W. Boyd; *Vice-President*—L. F. Kent; *Secretary*—A. H. Koch; *Treasurer*—W. J. McKinney; *Board of Governors*—T. T. Tucker and M. V. Crout.

Following the nominations the meeting adjourned.

MANITOBA MEMBERS MEET

October 17, 1940. The regular monthly meeting of the Manitoba Chapter was held at the Fort Garry Hotel, Winnipeg, with Pres. P. L. Charles presiding, and 15 members and guests present.

The minutes of the May meeting were read and approved, followed by brief remarks by the president, who welcomed the new members.

On motion by J. B. Steele, seconded by William Glass, it was decided to continue to hold the meetings at the Fort Garry Hotel.

Following a report on membership, Frank Thompson, chairman of the membership committee, submitted his resignation, which was accepted with regret. Mr. Thompson explained that it was due to the fact that he was moving from the city. Mr. Glass was then appointed as chairman of the membership committee.

Mr. Steele, chairman of research and publicity, gave a brief outline of the plans for the coming year. D. F. Michie gave a summary of what has been arranged to date regarding speakers for the meetings. Following this, the secretary read various correspondence which had accumulated during the summer.

Mr. Michie announced that he had heard from Pilot Officer P. H. Foster, who is now with the Royal Air Force in Scotland. It was then decided that the chapter should send some little remembrance to reach him by Christmas.

President Charles introduced Major L. L. Anthes, who made a few remarks, followed by adjournment.

W. L. FLEISHER ADDRESSES WESTERN NEW YORK

November 11, 1940. The second meeting of the season of the Western New York Chapter was held at the University Club with 54 members and guests present. The minutes of the October meeting were read and approved, and Pres. C. A. Gifford welcomed the members of the Air Conditioning Council of Western New York.

Joseph Davis was introduced as one of the directors of the new municipal auditorium.

L. P. Saunders was then introduced by President Gifford as the representative from the Western New York Chapter nominated to serve as a member of the Council for a three-year term.

W. P. Davis, executive secretary of the Air Conditioning Council of Western New York, extended an invitation to join with them for their meeting March 20 at the University Club.

M. C. Beman introduced the guest of the evening, Walter L. Fleisher, New York, 1st vice-president of the Society, who spoke on the practical research for air conditioning of air raid shelters, which was most interesting and timely. Following a discussion, the meeting was adjourned.

FORCED HOT WATER HEATING DISCUSSED AT WESTERN MICHIGAN

November 12, 1940. The November meeting of the Western Michigan Chapter of the Society was held at the Occidental Hotel, Muskegon, Mich., with dinner preceding the meeting which was attended by 37 members and guests.

Pres. T. D. Stafford called the meeting to order and the minutes of the October meeting were read and approved.

Announcement was made of the Society's 47th Annual Meeting in Kansas City, January 27-29, 1941.

Prof. L. G. Miller presented W. W. Bradfield, past president of the Chapter, with a plaque in a very fitting manner, for which Mr. Bradfield expressed his appreciation.

H. J. Young introduced the speakers of the evening, the Messrs. Moore, Pullum and Ruge, of Chicago. Mr. Pullum gave a very interesting and instructive talk, using a series of slides, followed by a question and answer discussion on the application of forced hot water heating which was lead by Mr. Moore.

W. G. Boales, Detroit, gave a short talk on the advantages of Society membership and all present were invited to join.

After considerable discussion the meeting adjourned at 10:20, according to the report submitted by F. C. Warren, secretary.

MICHIGAN MEMBERS MEET

November 4, 1940. The regular monthly meeting of the Michigan Chapter was held at Joey's Stables, with dinner preceding the meeting, and 50 members and guests in attendance.

Vice-Pres. Kilner announced that the speaker at the December meeting had been arranged for and that W. L. Fleisher, 1st Vice-President of the Society, would be the guest speaker.

Pres. G. H. Tuttle introduced Mr. Wallace, Superintendent of Filtration, Detroit Sewage Disposal Plant, who spoke briefly, and then introduced A. B. Morrill, engineer of sewage treatment. He gave a summary of the operations of the Sewage Treatment Plant and of the collecting system of sewers to the Plant. Following this, those present broke up in parties of about 12, and with members of the Plant staff as guides, were conducted on a tour through the Plant.

MASSACHUSETTS HOLDS JOINT MEETING

October 23, 1940. The October meeting of the Massachusetts Chapter was held jointly with the Boston Air Conditioning Bureau at the Massachusetts Institute of Technology, with 100 members and guests in attendance.

C. P. Yaglou, vice-president of the chapter, introduced A. D. Weston, who spoke on the registration and licensing of professional engineers, and the draft of permissive legislation drawn up by members of a committee appointed by the *Engineering Societies of New England*. A. L. Shaw, a member of this committee, discussed the bill briefly and was of the opinion that some sort of a bill was necessary and thought that the permissive type prepared by the engineers would be more to their liking than a mandatory one drawn up by others.

K. B. McEachron, not being able to be present, sent in his opinion, which was read at the meeting. While not in favor of registration, he felt that this bill would be acceptable if one was necessary.

Letters from A. C. Bartlett and F. R. Ellis were also read and their ideas were very similar to Mr. McEachron's. Prof. James Holt thought that some sort of a law would be inevitable and if this were true, this bill, in his opinion, would be more desirable than many that might be presented.

D. J. Edwards and Mr. Brown were very much against registration and did not think the draft should be accepted, but that the *Engineering Societies of New England* should carefully watch the proceedings of the legislature and kill any bill not acceptable to the professional engineers of Massachusetts.

W. T. Jones, past president of the Society, and A. S. Kellogg, thought that this bill should be accepted.

Messrs. Lincoln and Summers of the Boston Air Conditioning Bureau did not think it necessary to submit the bill at this time, but thought it should be ready for use only when and if legislation drawn up by others could not be defeated.

H. Brown, president of the *Engineering Societies of New England* was called upon to speak and stated that because of his position he was neutral, but thought that all engineers should consider the bill carefully and express their opinion when polled by the *ESNE*. Following Mr. Brown's talk the meeting was adjourned.

DRAFTSMEN SUBJECT TO WAGE-HOUR ACT

Revised definitions of executive, administrative, and professional personnel outside of the scope of the federal law regulating minimum wages and maximum hours of work do not include draftsmen "in the vast majority of instances," according to Col. Philip D. Fleming, Wage-Hour Administrator, as outlined in the *Bulletin* of the *American Engineering Council*. Such workers are normally, Colonel Fleming points out, paid on an hourly basis and perform routine work; they do not therefore fall into the professional category. The revised definitions are briefly as follows:

Exemption as a professional worker is limited to those paid at least $200 per month who are engaged in work predominantly intellectual and varied in character, as distinct from routine work, requiring the consistent exercise of discretion and judgment, and of such character that the output or result cannot be standardized in relation to a given period of time, except that not over 20 per cent non-exempt work may be performed as an incident to employment without forfeiting exemption. In addition, the work must either require knowledge of an advanced type in a field of science or learning, as distinguished from a general academic education, or must be predominantly original or creative in a recognized field of artistic endeavor.

Exemption as an administrative employee is granted only to workers paid $200 per month or more engaged in non-manual work which requires the exercise of discretion and independent judgment whose duties fall within one of three categories: (1) regular and direct assistant to an executive or another exempt administrative employee; (2) office or field work, under only general supervision, directly related to management policy or business operations, along specialized or technical lines requiring special training, experience, or knowledge; (3) execution of special assignments or tasks directly related to management policies or general business operations.

Exemption as an executive is granted only to those meeting all of the following requirements: The employee's primary duty must be the management of the establishment, or a department or subdivision thereof; he must customarily direct the work of others; he must regularly exercise discretionary powers; must have the power to hire or fire and promote; must receive a salary of at least $30 per week; may perform no more than 20 per cent of his work in activities

normally performed by non-exempt employees.

MEMBERS ENJOY DELTA CHAPTER LUNCHEON

When the Delta Chapter was organized the board of governors inaugurated luncheon meetings for the transaction of chapter business instead of the conventional hour before monthly chapter meetings. These meetings are held at Maylies restaurant, New Orleans, at noon on the third Tuesday of each month, exactly two weeks before and two weeks after the regular chapter meetings. Later the membership at large was invited to these luncheons with the idea of maintaining a luncheon club that would function during the 12 months of the year.

According to the report of G. E. May, president of the chapter, these meetings have been so successful that this year as many as 55 per cent of the chapter membership have been present and 75 per cent of the members in New Orleans have attended. It is the wish of the Chapter officers to extend an invitation to every Society member visiting New Orleans to join the luncheon group or attend the regular evening meeting.

ASTM SPECIFICATIONS FOR PIPE AND PIPING MATERIALS

A compilation of specifications for pipe and piping materials consists of 24 of the 40 *ASTM* specifications used in high-temperature and high-pressure services. This 154 page book provides in convenient form standards which are important to those concerned with power plants and industrial installations of piping materials. It is widely used in other connections by manufacturers and purchasers of materials.

Eleven of the twenty-four specifications cover various types of carbon and alloy steel pipe and boiler tubes, etc., including the specifications for classication and dimensions of wrought iron and wrought steel pipe. Four items cover carbon and alloy steel castings, three pertain to bolting materials including nuts, and there are four items covering forgings and welding fittings. The classification of austenite grain size in steels with two grain size charts is also included.

Copies of this publication in heavy paperboard cover with special ring binding are available from *ASTM* Headquarters, 260 S. Broad St., Philadelphia, Pa., at $1.25 per copy.

DEATH OF JAMES A. PIETSCH

James Anderson Pietsch, consulting engineer of New Brighton, Staten Island, N. Y., died at the age of 65 on December 15, at his home, 155 Prospect Street. He was born in Brooklyn, June 24, 1875 and received his early education in Brooklyn Public Schools and graduated with degrees of B.S. and E.E. from Brooklyn Polytechnic Institute, Rutgers University and Sheffield Scientific School, Yale University.

Since 1925 he has built many apartment houses and homes on Staten Island where he acted as consulting and construction engineer. Most of the preceding 25 years he spent in West Indies, Central America, and South America where he designed and built power plants, water works, docks, schools, churches, barracks and homes. As chief engineer and general superintendent on various utilities and construction companies he supervised and installed construction work costing several hundred millions of dollars.

Mr. Pietsch held membership in the *American Institute of Electrical Engineers*, American Society of Heating and Ventilating Engineers; he was a director of the *New York State Society of Professional Engineers*, former vice president of the Richmond County Chapter and was an officer of the *General Building Contractors Association of Staten Island*.

His many associates regret his untimely death and the Officers and Council of the ASHVE have expressed their sincere sympathy to his family who survive, Mrs. Elizabeth Pietsch, his son James, his brother and sister.

Candidates for Membership

The Constitution of the Society, as now amended, requires the following mode of procedure in voting on applicants for membership in the Society. All applications for membership are to be sent to the Secretary and the names of applicants and their references shall be printed in the next issue of the Journal of the Society or sent to the members in other approved manner as ordered by the Council. When replies are received from references, the Candidate's application shall be submitted to and acted upon by the Committee on Admission and Advancement as soon as possible.

When the Committee on Admission and Advancement has acted favorably upon a Candidate's application and assigned his grade, the Council shall vote upon the election of the proposed Candidate for membership by letter ballot. During the past month 20 applications for membership have been received and the names of these men and their sponsors are published in the following list.

Members are requested to scrutinize the list with care. The Committee on Admission and Advancement, and in turn, the Council, urge the members to assume their share of responsibility of receiving these candidates into membership by advising the Secretary promptly of any whose eligibility for membership is in any way questioned.

All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote.

Unless objection is made by some member by January 15, 1941, these candidates will be balloted upon by the Council. Those elected to membership will be notified by the Secretary immediately after election.

CANDIDATES	REFERENCES	
	Proposers	*Seconders*
Ahrens, Richard H., Sales Engr., Green Foundry & Furnace Wks., Davenport, Ia.	A. L. Walters W. J. Hennessy	F. R. Vaughn E. N. Danielson
Converse, Thornton J., Supvr., Douglas Orr—Architect, New Haven, Conn.	E. J. Rodee L. A. Teasdale	D. Orr (*Non-member*) G. H. Eaton (*Non-member*)
Crumley, Mearl T., Engr., Robert & Co., Atlanta, Ga.	A. O. Blackman F. C. McIntosh	F. E. Markel (*Non-member*) R. Brauer

CANDIDATES

DOLAN, WM., H., Pres.-Treas. & Gen. Mgr., The Jennison Co., Fitchburg, Mass. (*Reinstatement*)

DOWDELL, JOSHUA R., Mfrs. Repr., J. R. Dowdell & Co., Dallas, Texas

FITZSIMONS, J. PATRICK, Mgr. (Air Cond. Dept.), Trane Co., of Canada, Ltd., Toronto, Ont., Canada. (*Advancement*)

FULLER, ROGER A., Commercial Engr., General Electric Co., Lynn, Mass.

HAMIG, LOUIS L., Engr., John D. Falvey, St. Louis, Mo. (*Advancement*)

HANSEN, JOHN T., Sales Repr., The Herman Nelson Corp., Moline, Ill.

HATCH, OSCAR J., Dept. Mgr., Clare Bros., Western Ltd., Winnipeg, Man., Canada.

HERRE, HOWARD M., Student, Carnegie Institute of Technology, Pittsburgh, Pa.

LESSINGER, EDGAR F., Owner, Lessinger Plumbing & Heating Co., Boise, Ida.

MART, LEON T., Pres., The Marley Co., Kansas City, Mo.

McBRIDE, J. NEVINS, Salesman, Frank A. McBride Co., Patterson, N. J.

MURPHY, DELACOUR I., Htg. Engr., American Radiator & Standard Sanitary Corp., San Francisco, Calif.

OTTO, ROBERT W., Mech. Engr., Toltz, King & Day, Inc., St. Paul, Minn. (*Reinstatement*).

POST, NICHOLAS, Army Ordnance Inspector, War Dept., St. Louis Ordnance Dist., St. Louis, Mo.

RUSSELL, BOYD A., Partner, Takoma Engrg. Co., Silver Spring, Md.

SIMPSON, ROBERT L., Htg. Engr., Crane Co., Philadelphia, Pa.

SMITH, CLIFFORD F., JR., Student, Carnegie Institute of Technology, Pittsburgh, Pa.

REFERENCES

Proposers	*Seconders*
R. T. Kern H. M. Tarr	E. G. Carrier W. T. Jones
M. L. Brown W. H. Moler	S. Pines R. Werner
S. A. Jennings J. W. O'Neill	G. E. Cole H. G. Hill
D. W. McLenegan F. H. Faust	R. U. Berry R. M. Ekings, Jr.
J. D. Falvey L. J. DuBois	E. E. Carlson J. H. Carter
N. B. Delavan C. W. Helstrom	L. E. Hedeen P. R. Duitch
I. McDonald P. L. Charles	J. R. Stephenson R. L. Kent
C. M. Humphreys T. F. Rockwell	D. C. Saylor (*ASME*) P. A. Edwards
J. F. McIndoe B. W. Farnes	T. E. Taylor B. W. Moore
W. L. Cassell E. M. Jolley	J. H. Kitchen H. Nottberg, Jr.
W. Fleisher F. L. Pryor (*Non-member*)	Gilbert Tanis (*Non-member*) J. Wheeler, Jr.
G. M. Simonsen C. E. Bentley	J. Gayner N. H. Peterson
H. E. Gerrish G. C. Morgan	B. H. Bjerken Wm. McNamara
E. E. Carlson L. J. DuBois	L. L. Hamig J. S. Rosebrough
H. R. Iverson L. F. Nordine	L. Bert Nye, Jr. A. E. Stack
H. Erickson A. E. Kriebel	C. Fred Dietz M. F. Blankin
C. M. Humphreys T. F. Rockwell	D. C. Saylor (*ASME*) P. A. Edwards

Candidates Elected

In the past issues of the JOURNAL of the Society the names of the following men were listed as Candidates for Membership. The membership grade of each Candidate has been assigned by the Committee on Admission and Advancement and balloted upon by the Council. We are now instructed by the Council to post herewith, as required by Art. B-III, Sec. 8, of the By-Laws, the following list of candidates elected:

MEMBERS

BRANDT, ALLEN D., P. A. Sanitary Engr., U. S. Public Health Service, National Institute of Health, Bethesda, Md.

JALONACK, IRWIN G., Chief Engr., Alfred L. Hart, Inc., Jamaica, L. I., N. Y. (*Advancement*)

JOHNSON, RALPH B., Owner, Ralph B. Johnson & Co., Houston, Tex. *(Reinstatement)*

KELSEY, HAROLD D., Engr., General Electric Co., Bloomfield, N. J.

LUDLOW, HAROLD M., Sales & Engrg., Jackson, Miss.

ASSOCIATES

BADHE, JAIKRISHNA MURLIDHAR, Asst. Engr., Volkart Bros., Ballard Estate, Bombay, India.

BLAIR, DONALD W., Engr., Boston Edison Co., Boston, Mass.

CUMMISKEY, JEROME F., Sales Engr., Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.

CUSHING, R. C., Sales Engr., Minneapolis-Honeywell Regulator Co., San Francisco, Calif.

LAVORGNA, MICHAEL, Sales Mgr., L. J. Mueller Furnace Co., Milwaukee, Wis.

MILLS, DANIEL M., Sales Repr., F. J. Evans Engineering Co., Birmingham, Ala.

WOODS, CHARLES F., Sales Repr., Southern Union Utilities Co., Bellville, Tex.

JUNIORS

ASH, ROBERT S., Htg. Engr., James B. Clow & Sons, Chicago, Ill.

AY, EDWARD L., Asst. Engr., Library of Congress, Washington, D. C.

DeLAUREAL, WM. D., Air Cond., Sales Engr., Fairbanks Morse & Co., New Orleans, La.

HUGHES, SAMUEL, Estimator, Minneapolis Gas Light Co., Minneapolis, Minn.

LA RAUS, JULIUS, Engr., Jowein, Inc., Jamaica, L. I., N. Y.

LUNN, ROBERT J., Donaldson Air Cleaner Corp., Minneapolis, Minn.

NUSBAUM, S. RICHARD, Mgr., Pennsylvania Engrg. Co., Philadelphia, Pa.

RAMSEUR, VARDRY D., JR., Htg. Engr., Ramseur Roofing Co., Greenville, S. C.

STURM, WILLIAM, Draftsman, Gausman & Moore, St. Paul, Minn.

STUDENTS

CAIN, WM. J., Student, Air Conditioning & Refrigeration Institute, St. Louis, Mo.

DICK, HAROLD, Refrigeration Serviceman, S. & S. Refrigeration, Jersey City, N. J.

ORGELMAN, G. H., Student, Yale University, New Haven, Conn.

STEIN, JEROME, Student, Yale University, New Haven, Conn.

VOLK, GEORGE H., Student, University of Wisconsin, Madison, Wis.